



Sofia Offshore Wind Farm

Environmental Appraisal of Increased Hammer Energy: Main Report

2020

Document Ref: 003230484-02



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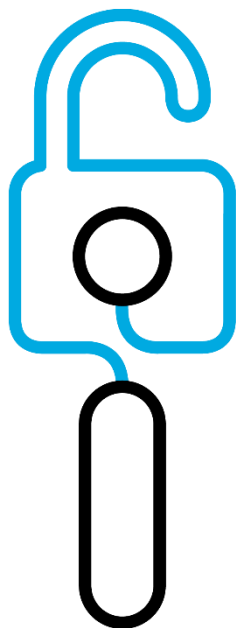
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APPENDICES (SEPARATE REPORTS)

Appendix A: Underwater noise modelling at Sofia Offshore Wind farm (Document ref: 003230547-01)

Appendix B: Cumulative Auditory Injury Assessment: cumulative exposure to piling noise (Document ref: 003230610-01)

Appendix C: Assessment of fish receptors (Document ref: 003230411-01)

Appendix D: Consultation Summary (Document ref: 003230672-01)

Appendix E: Updated SNS SAC shadow HRA Information for BEIS (Document ref: 003457206)

Executive Summary

This report represents an Environmental Appraisal of a proposed increase in maximum hammer energy to be used on the Sofia offshore wind farm project from a consented 3,000kJ to a proposed maximum of 4,000kJ, for monopole foundations only. The information contained within this report and its supporting Appendices has been developed to provide the regulator (and relevant stakeholders) with the necessary information to determine whether the proposed changes to the scheme represent a material change to the original scheme for which the consent was awarded. This has been achieved through a comparison exercise of the effects predicted within the original consent application material to those predicted as a result of the increased maximum hammer energy for monopole foundation solutions.

It is important to note that in June 2018 SOWFL undertook an Environmental Appraisal to support a similar non-material amendment application for a hammer energy increase of up to 5,500kJ (doc ref 00263963-03) as part of a number of changes to the consented envelope (those other aspects being:

- for each wind turbine generator to have a maximum rotor of up to 288 metres rather than up to 215 metres;
- for gravity base, multileg or monopole foundations for offshore platforms with monopole foundations of up to 12 metres diameter;
- to restrict the combined number of monopole foundations for the wind turbine generators and platform to the existing number of 200; and
- to increase the maximum generating capacity up to 1.4 GW from 1.2 GW.

Approval for the amendments list in bullets above was secured from the Department of Business, Energy and Industrial Strategy (BEIS) on 25th March 2019. Following discussions with the Marine Management Organisation (MMO) and BEIS in February 2019, SOWFL took a decision to exclude the 5,500kJ variation request in February 2019 as part of the final suite of amendments due to the potential delay of the determination of the request due to its linkage with the consultation on the wording for the Marine Licence Site Integrity Plan Condition, which was undertaken as a result of the Southern North Sea SCI Review of Consents.

In the intervening period since retracting the 5,500kJ application SOWFL have engaged further with the construction supply chain and also undertaken further internal desk based engineering appraisal work of the site and have concluded that increasing maximum hammer energy to 5,500kJ would be overly precautionary and that a limit of 4,000kJ would be a more appropriate (yet still precautionary) maximum level. Therefore, this non-material amendment has been brought forward on the basis that the maximum hammer energy required at any location for the installation of piled monopoles would be no greater than 4,000kJ.

SOWFL undertook considerable consultation on the outputs of the 5,500kJ hammer energy increase work in 2018, and secured agreement from the statutory nature conservation body (SNCB, namely Natural England) and the regulator (the MMO) that the proposed increase in hammer energy did not represent a material amendment change. All modelled impact ranges for this 4,000kJ hammer energy increase proposal are less than those predicted for the 5,500kJ scenario, therefore, the conclusions reached under that original process remain valid but with added precaution. The findings of this report therefore, demonstrate that the proposed increase in maximum hammer energy will not result in any significant or new impacts and the proposed increase in hammer energy can be considered non-material.

This Environmental Appraisal is supported by a number of technical Appendices (Appendices A-E), a number of which have been adapted from the technical information presented within the development of the original 5,500kJ proposal. A record of key consultation (Appendix D) undertaken on the 5,500kJ proposal is also included within this application as it has direct relevance to the work undertaken and will help facilitate an efficient consultation process on this 4,000kJ submission.

1 Sofia Offshore Wind Farm

Sofia offshore wind farm (formally Teesside B) forms one of four consented projects within the Dogger Bank Zone. The Dogger Bank Zone comprises an area of 8,660km², located in the North Sea between 125km and 290km off the coast of Yorkshire. In August 2017 Innogy, previously one of four partners in the Forewind consortium, which obtained consent for the project, secured 100% ownership of the project.

The Development Consent Order (DCO) (SI 2015 No. 1592) (the “Order”) for Sofia was granted on the 4th August 2015 and came into effect on 26th August 2015. The DCO was amended in March 2019.

Sofia has consent for up to 200 wind turbines with a total installed capacity of 1.4GW. The export cable will reach landfall along the Teesside coastline between Redcar and Marske-by-the-Sea. Offshore site investigations for the project may commence at the earliest from 2020 and therefore, this assumption has applied within the in-combination assessment.

Piling (also referred to as percussive piling or impact piling) is permitted under the existing DCO for the installation of the foundations for the wind turbine generators (WTGs), however, as a result of engineering refinement and project optimisation, Sofia Offshore Wind Ltd (SOWFL) is seeking to make a non-material variation to the consented parameters with regard to an increase in hammer energy in order to ensure successful monopole foundation installation. This document has therefore been prepared in support of an application for non-material amendments to the Order pursuant to section 153 and schedule 6 of the Planning Act 2008 and for variations of the Deemed Marine Licences (dML) pursuant to section 72(3) of the Marine and Coastal Access Act 2009. The requirement for a non-material amendment to the DCO for Sofia is considered to be required since the maximum hammer energy permitted during construction is specified on the face of the DCO. This document sets out details and comparative assessment to inform the environmental implications of bringing forward the increase in hammer energy for monopole installation at the project.

1.1 Document Structure

This document is set out as follows:

- Section 1: Introduction to the Sofia Offshore Wind Farm;
- Section 2: Background to the need to vary the maximum consented hammer energy;
- Section 0: Consented Design Envelope and the Change being Sought;
- Section 4: Method of Comparison - how the original noise modelling, which supported the DCO application, has been compared to the revised noise modelling undertaken;
- Section 5: Environmental Appraisal – Screening of the ES to identify impacts affected by the revised project design;
- Section 6: Impact Assessment - a detailed discussion of these impacts;
- Section 7: Consideration of The Habitats Regulations;
- Section 8: Conclusions – A brief summary of the relevant findings and conclusions;

Supporting Appendices:

- Appendix A: Underwater noise modelling at Sofia Offshore Wind farm (separate document);
- Appendix B: Auditory Injury Assessment: cumulative exposure to piling noise (separate document);
- Appendix C: Assessment of fish receptors (separate document);
- Appendix D: Consultation Summary (separate document); and
- Appendix E: Updated SNS SAC Information for BEIS (separate document).

2 Background

As noted above, piling is permitted under the Sofia (dML), within the Sofia DCO, for the installation of the foundations for the offshore infrastructure required for the project. The infrastructure that may require piling includes wind turbine generator (WTGs) foundations, offshore converter stations, offshore collector platforms, met masts and accommodation platforms.

The Sofia consent is based on a maximum hammer energy of 3,000kJ for piling of monopole foundations, which is stated on the face of the DCO (Schedule 1, Part 3, 6, (2)(B) of the DCO and Schedule 9, Part 2, 6, (2)(B) of the dML). SOWFL has identified that there may be a technical requirement to increase this maximum hammer energy and therefore needs to vary the existing consent to reflect this. In light of this, GoBe Consultants Ltd. has drafted this document to inform the environmental implications of adopting an increased maximum hammer energy for piling of monopole foundations at Sofia to 4,000kJ. To support this variation of consent, this report will provide supporting environmental information to demonstrate whether the proposed increase in hammer energy will result in any change in the predictions made within the Environmental Statement (ES), and in particular to determine if the change would result in any impacts significantly greater than those originally determined within the ES.

SOWFL wish to secure formal approval of the conclusions set out in this paper so that the project can proceed with regulatory agreement that the planned construction activities at Sofia will not result in any greater impacts than those originally determined within the ES.

As part of this process, underwater noise modelling predictions that informed the original Sofia impact assessment (as referred to within the application for consent)¹ have been compared with those derived from new modelling, which assess the noise propagation extents for the proposed increase in hammer energy that will be required for the successful installation of monopole foundations at the site. The original underwater noise modelling undertaken to inform the Sofia impact assessment that supported the DCO application was undertaken by the National Physical Laboratory (NPL) and completed in 2013. The updated noise modelling has been undertaken by Subacoustech Environmental Ltd. (Subacoustech) and was completed in 2018 (Appendix A (Subacoustech Environmental Report No. P221R0104) to this Environmental Appraisal report (Separate Report)), noting that this modelling in 2018 (to support the 5,500kJ work) also included consideration of 4,000kJ maximum hammer energy scenarios.

The initial (5,500kJ) hammer energy increase sought to undertake a like for like assessment of the underwater noise modelling (as set out above), but following consultation with Natural England and the MMO this was extended to cover a number of further scenarios to reflect requests for the modelling to:

- Have due regard to the latest underwater noise threshold guidance and model cumulative exposure to piling (this was presented in Appendix B (Ecodoc Ref 002668408-01) to this Environmental Appraisal report (Separate report));
- Consider modelled impact ranges of fish receptors (this was presented in Appendix C (Ecodoc Ref 002668403-01) to this Environmental Appraisal report (Separate report)); and
- Consider modelled impact ranges on fish receptors assuming receptors were static (this was presented within Appendix A of the Statement of Common Ground between SOWFL and the MMO, as signed on the 20th November 2018 (doc ref 0027266144-04).

¹ <https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010051/EN010051-000250-6.5.1%20ES%20Chapter%205%20Appendix%20A.pdf>

This Environmental Appraisal report builds directly on the original appraisal, reporting and consultation work undertaken for the 5,500kJ hammer energy increase proposals. Therefore, where relevant the material has been kept largely the same and only updated to reflect the smaller increase to the maximum hammer energy. Outputs from the additional work undertaken in response to stakeholder comments (as cited above) have been brought directly into this main report. Table 2.1 identifies the supporting modelling work that has been used to inform this 4,000kJ Environmental Appraisal report to enable a clear audit trail for stakeholders between the original work undertaken as part of the 5,500kJ appraisal and this latest 4,000kJ appraisal.

Table 2.1: modelling work to support the 4,000kJ Environmental Appraisal

Work Item	Detail & Context	Location within this report
ES comparison noise modelling	4,000kJ scenarios were considered within the Subacoustech modelling report (presented at Appendix A of the 5,500kJ Environmental Appraisal document) and therefore, the report remains valid for this application. 4,000kJ outputs have been highlighted within this version of the report and 5,500kJ outputs removed to avoid any confusion.	Technical report included at Appendix A (separate report)
SELcum modelling for marine mammals	4,000kJ scenarios were considered by subacoustech as part of the modelling that was undertaken to inform this report (which was submitted at Appendix B of the Environmental Appraisal report for the 5,500kJ work). The report has been updated to reflect the 4,000kJ outputs and 5,500kJ information removed.	Technical Report included at Appendix B (separate report)
Modelling for fish receptors	4,000kJ scenarios were considered by subacoustech as part of the modelling that was undertaken to inform this report (which was submitted at Appendix B of this Environmental Appraisal report for the 5,500kJ work). the report has been updated to reflect the 4,000kJ outputs and 5,500kJ information removed.	Technical Report included at Appendix C (separate report)
Static fish modelling	Modelling of underwater noise impacts assuming fish remain static was undertaken as part of the latter stage consultation on the 5,500kJ appraisal in response to specific requests from the MMO. No modelling of 4,000kJ scenarios were undertaken as part of this. Therefore, new modelling applying the same assumptions but with a maximum 4,000kJ hammer energy has been undertaken and the outputs are presented within the main fish modelling report.	Included within the Technical Report presented at Appendix C (separate report)

3 Consented Design Envelope

The ES as submitted with the application included a worst case design envelope (its ‘Rochdale Envelope’), as summarised in Table 3.1 for the offshore infrastructure requiring piling. It is important to reiterate that the increased maximum hammer energy would only be applicable to monopole foundation locations.

Table 3.1: Sofia offshore wind farm maximum design parameters.

Parameter for HRA	Consented
Piling	
Construction timeframe	To commence with 7 years of consent (August 2015)
Construction duration	6-year construction window as a maximum with the piling window covering 2-3 years within that timeframe
Piling duration (max and average) per foundation type including soft start of 30 mins	3.5 hours (pin pile) 5.5 hours (monopole)
Foundation types	Pin pile or monopole
Max number of foundations and piles	200 WTGs = 200 monopoles. 1,200 if pin piles (jackets). 5 met masts = 5 monopoles. 20 if pin piles. 4 Offshore Collector Platforms = 96 pin piles 1 Offshore Converter Platform = 24 pin piles 2 Accommodation Platforms = 48 pin piles
Construction scenarios	Sequential or concurrent
Layout	Across whole order limits

The Sofia ES considered a worst case maximum hammer energy of 3,000kJ for the installation of monopole foundations. However, SOWFL has identified that there may be a technical requirement to increase this maximum hammer energy to 4,000kJ for monopole installation only.

The proposed increase in maximum hammer energy means that there is a potential change in the maximum underwater noise impact risk ranges when compared to that resulting from the original Sofia Design (“Rochdale”) Envelope, (as summarised in Table 3.1 above) and cited within the project’s DCO/deemed Marine Licences (dMLs). To address the requirement, a non-material amendment of the Development Consent Order (DCO) is sought to vary the maximum hammer energy stipulated on the face of the DCO (and where relevant, the dMLs). A draft amendment Order to give effect to the proposed DCO changes has been provided along with the application.

There is no statutory definition of what constitutes a material or non-material amendment for the purposes of Schedule 6 to the Planning Act 2008 and Part 1 of the 2011 Regulations. Criteria for determining whether an amendment should be material or non-material is outlined in the Department for Communities and Local Government (DCLG’s) “Guidance on Changes to Development Consent Orders” (December 2015). The following characteristics are stated to indicate that an amendment is more likely to be considered material’.

- 1) Where any new or significant effects on the environment as a result of the change mean that an update to the original Environmental Statement (from that at the time the original DCO was made) is required (to take account of those effects);
- 2) Where the impact of the development to be undertaken as a result of the proposed change introduces the need for a new Habitats Regulations Assessment, or the need for a new or additional licence in respect of European Protected Species (EPS) (in addition to those at the time the original DCO was made);
- 3) Where the change would involve compulsory acquisition of any land or an interest in or rights over land, that was not authorised through the existing DCO; or

- 4) The potential impact of the proposed changes on local people will also be a consideration in determining whether a change is material.

The proposed variation to the DCO in relation to increase in hammer energy has been considered herein with reference solely to the first of these requirements, as the other characteristics are not relevant for the purposes of this report.

4 Method of Comparison

This environmental assessment has been undertaken to assess the potential for an increase in the hammer energy at Sofia from 3,000kJ to 4,000kJ for monopole foundations, which could result in a change in the level of significance from that presented within the ES. This assessment has been undertaken via means of screening and an impact assessment. The screening considers whether receptors are likely to be impacted by the changes in hammer energy. Where no additional, new or different impact to that assessed in the original environmental assessment is identified, or the impact is expected to be negligible, the receptor is screened out from further consideration. In all other cases, the receptor is considered further, with the potential impacts assessed, taking account of the likelihood of the impact occurring, the sensitivity of the receptor and the magnitude of the potential effect. In doing this, consideration has also been given as to whether the nature or level of the impact will significantly exceed that previously assessed and consented.

4.1 Underwater Noise Modelling

The original underwater noise modelling for the Sofia ES was undertaken by NPL who used an energy flux solution model (Weston 1976) to predict the impact risk range of underwater pile driving noise. Modelling was undertaken for the worst case hammer energies operating at 2,300kJ for pin pile foundations and 3,000kJ for monopole foundations. Additionally, a number of lower hammer energies were modelled to represent soft-start and ramp up energies. The results produced by NPL considered the following species groups:

- Low frequency and mid frequency cetaceans and pinnipeds (applying thresholds drawn from Southall *et al.* (2007));
- High frequency cetaceans (harbour porpoise) (applying thresholds drawn from Lucke *et al.* (2009));
- Injury in species of fish (applying values drawn from Popper *et al.* (2006) and Carlson *et al.* (2007));
- Behavioural response in species of fish (applying values drawn from McCauley *et al.* (2000) and Pearson *et al.* (1992)).

The NPL noise modelling undertaken for Sofia is presented at Appendix 5A of the ES². The model employed by NPL in the Sofia ES is not openly available and as a result, the INSPIRE model has been utilised by Subacoustech to produce comparable modelling results for Sofia for the 4,000kJ hammer energy. INSPIRE is semi-empirical underwater noise propagation modelling software which incorporates depth-dependency and a combination of numerical data modelling and actual measured data.

Stage 1 of the assessment comprised two steps. The first was a like for like comparison, to confirm the suitability of the INSPIRE model by applying the same input parameters and scenarios as used in the NPL model and verifying comparability between the output results. The second step was to use INSPIRE to model the greater hammer energy scenarios in order to assess the consequences of using a higher energy at Sofia for monopole installation to complete Stage 1 in comparison to the consented case, whilst adopting the same metrics and thresholds used in the Sofia ES.

Modelling undertaken by Subacoustech was based on piling undertaken at a single location at the northernmost boundary of the Sofia site. This site is in some of the deepest water (32 m) at the Sofia site. The ranges calculated are considered

² <https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010051/EN010051-000250-6.5.1%20ES%20Chapter%205%20Appendix%20A.pdf>

to represent the worst case for the purposes of this assessment as the deepest water location typically results in the greatest underwater noise propagation. The impact risk ranges produced by the INSPIRE model allow a direct comparison with the impact risk ranges produced by the NPL model.

The results of this comparison between the NPL and INSPIRE models showed a good level of correlation between the datasets (Appendix A Section 2.3 (separate report)), thus verifying that the INSPIRE model can be relied upon for the subsequent comparative modelling of higher hammer energies for the purposes of comparison. The results of the modelling for the higher hammer energies from the INSPIRE model therefore allow for conclusions to be drawn as to whether or not any changes in ecological effect relating to an increase in hammer energy for the foundation installations at Sofia are material.

Stage 2 of the assessment incorporates new criteria (which have been published since the Sofia ES) developed by the US National Marine Fisheries Service (NMFS) for impacts on marine mammals (NMFS, 2016), into the INSPIRE model. This allows consideration of the potential for an effect on relevant receptors based on the most contemporary data and assessment methodologies, as well as comparison with the findings of the Stage 1 assessment. Further detail on the assessment process is presented, as relevant, in the sections below.

5 Screening

The Sofia ES has been reviewed to identify those receptors that were highlighted as being sensitive to offshore piling noise impacts and hence the assessment outcomes which need to be considered as part of the assessment of the increased maximum hammer energy. This appraisal only considers the noise impacts from offshore piling during the construction phase of the project. Noise impacts from other construction activities (e.g. vessel engines) and other phases of the project’s lifetime (e.g. operation and decommissioning) will be unaffected by the increased hammer energy as the consent envelope remains the same for these factors. These scenarios are therefore not considered further in this document.

As part of the original EIA process, screening was undertaken to identify potential impact pathways and hence the relevant receptors, that could be affected by offshore piling. Within this appraisal those receptors for which there was no identified impact pathway for underwater piling noise impacts (and for which, therefore, no assessment of the impacts of noise was undertaken within the ES), have been excluded.

As part of the current appraisal, a further screening exercise has been carried out to determine if there is the potential for the assessment of the significance of the effect to be changed by the proposed increased hammer energy. This screening exercise is presented in Table 5.1 along with justification as to whether any further consideration needs to be given to the impacts of an increased hammer energy.

Table 5.1 - Screening of ES Chapters that considered the impacts of underwater noise from piling to determine the potential for any change to the conclusions of each Chapter from the proposed increased hammer energy.

ES Chapter	Potential for change to ES conclusions due to increased hammer energy	Justification
Designated Sites (Chapter 8) and Habitats Regulations Assessment (HRA doc Ref 5.2)	No	The Designated Sites chapter of the ES considered the effects of construction activity impacts on nature conservation areas and protected species however, all impacts assessed in this chapter are drawn from findings from the relevant chapter of the ES (e.g. Fish and Shellfish, Marine Mammals and Ornithology) and as such are covered in the relevant sections identified below. Specific consideration to the HRA is given in Section 7 of this report.

ES Chapter	Potential for change to ES conclusions due to increased hammer energy	Justification
Fish and Shellfish Ecology (Chapter 13)	Yes	The main findings of the ES chapter for underwater noise impacts on sensitive fish receptors are presented below. This includes a consideration of the ES findings in relation to the increase in the maximum hammer energy.
Marine Mammals (Chapter 14)	Yes	The main findings of the ES chapter for underwater noise impacts on marine mammals are presented below. This includes a consideration of the ES findings in relation to the increase in the maximum hammer energy.
Transboundary Effects (Chapter 32)	No	The Transboundary Effects chapters of the ES considered the effects of construction activity impacts on transboundary species however, all impacts assessed in this chapter are drawn from findings from other receptor lead chapters such as the Fish and Shellfish Resources (Chapter 13). As such, this chapter is not considered any further here.

6 Impact Assessment

The following sections present an environmental appraisal comparing the assessment presented within the ES for a 3,000kJ hammer energy (based on the NPL modelling) with that of an increased hammer energy for 4,000kJ (based on the modelling undertaken by Subacoustech). Each assessment is presented in two stages – Stage 1 being a like for like comparison, Stage 2 applying the revised metrics.

6.1 Fish and Shellfish Resources (Environmental Statement Chapter 13)

Fish and Shellfish (Sofia ES Chapter 13)

Table 5.2 of the Fish and Shellfish Resources Chapter (Chapter 13) identifies pin piles as the worst case scenario based on the high number of piling events associated with the installation of jacket foundations (up to six piling events per foundation compared to one piling event for monopoles). This worst case therefore represents the maximum duration of piling events instead of the greatest impact risk range associated with a single piling event. Chapter 13 acknowledges that the temporal disturbance (i.e. maximum duration) from construction noise will have a greater effect on fish and shellfish than the maximum noise range disturbance. The worst case is summarised below.

- 200 x 6 pin pile foundations (3.5m pin piles; jacket foundations for WTGs; 1,200 piles) at maximum 2,300kJ hammer energy
- 5 x 4 pin pile foundations (3.5m diameter pin piles, jacket foundation for met masts; 20 piles) at maximum 1,900kJ hammer energy

- 4 x 24 pin pile foundations (2.75m diameter pin piles, jacket foundation for Offshore Collector Platform; 96 piles) at maximum 1,900kJ hammer energy
- 1 x 24 pin pile foundations (2.75m diameter pin piles, jacket foundation for Offshore Converter Platform; 24 piles)
- 2 x 24 pin pile foundations (2.75m diameter pin piles, jacket foundation for Accommodation platform; 48 piles) at maximum 1,900kJ hammer energy
- Maximum of 2 simultaneous piling operations;

The duration of piling (including soft-start) for pin pile foundations is approximately 202 days which is significantly greater (by 185%) than the 71 days required for the piling of monopole foundations. As identified in the ES, the temporal aspect of underwater noise is considered to have the greatest effect on fish and shellfish species.

The intension of this environmental appraisal is to evaluate the potential impact associated with an increase in maximum hammer energy for monopole foundations only. The ES identified (in agreement with Natural England and the MMO), the worst case for fish and shellfish was temporal and therefore derived from pin pile foundations, fish and shellfish should not be assessed any further as the proposed increase in hammer energy is only relevant for monopole foundation installation. However, it is recognised that whilst Natural England supported this approach for the 5,500kJ appraisal work, the MMO wished to see the potential impacts on fish receptors modelled irrespective of the agreed worst case assumptions, and this was subsequently undertaken by SOWFL. Whilst SOWFL consider the worst case assumptions as agreed on the original application should remain valid (and therefore, not necessitate further assessment), modelling for the 4,000kJ hammer energy increase has been undertaken based on criteria advised by the MMO and CEFAS and are presented in Appendix C.

It is noted that certain ornithological receptors were considered sensitive to underwater noise as an indirect consequence of potential changes in prey resource (fish). Given the fact that the hammer energy increase does not affect the worst case assumptions relating to fish as detailed in Appendix C using either a stationary or fleeing model, there would be no indirect consequence for any ornithological receptors either.

6.2 Marine Mammals (Environmental Statement Chapter 14)

As defined in Table 5.2 of Chapter 14; the worst case scenario for spatial extent effects is based on maximum hammer energy for monopole foundations as this produces the largest impact risk footprint for marine mammals. The realistic worst case scenario is as follows:

- 100% pile driving monopoles;
- Pile diameter: 12m Max Penetration: 55m;
- Max Blow Force: 3,000kJ;
- Soft-start duration: 0.5 hours;
- Soft-start hammer energy: 300kJ; and
- Total max pile driving duration: 5 hours 30minutes (full force time per pile 5 hours, soft-start 30minutes).

A second scenario (construction phase) is also given in the ES (Table 5.2 of Chapter 14), based on the installation of pin pile foundations as representing the worst case for piling duration due to the longer period over which piling noise would be generated. The proposed increase in hammer energy will not affect any assessment for pin pile foundation installation as the larger hammer will only be used for monopole installation. This aspect is, therefore, not considered further in this appraisal document.

The ES chapter assessed the impacts of noise from pile driving on grey seal (*Halichoerus grypus*), harbour porpoise (*Phocoena phocoena*), minke whale (*Balaenoptera acutorostrata*) and white-beaked dolphin (*Agenorhynchus albirostris*).

Both cetaceans and pinnipeds are vulnerable to impacts of piling noise, with impacts including lethal or physical injury, hearing injury and disturbance, depending on the received noise levels. Hearing injury in marine mammals depends on the sensitivity of the species and factors such as the duration, frequency and level of the noise. Hearing injury can manifest itself as a temporary threshold shift (TTS), where the ability of the individual to hear at certain frequencies is reduced temporarily before fully recovering, and as a permanent threshold shift (PTS) or a permanent change in the ability of an individual to hear at certain frequencies. In terms of the impact on the species present, non-lethal effects (including

behavioural) were defined within the ES as having the potential to be significant if this resulted in the avoidance of important feeding or breeding grounds.

6.3 Stage 1 – Sofia ES Modelling Results

This section considers the potential impacts to marine mammals in relation to the proposed increased hammer energy and assesses whether an increase in maximum hammer energy from 3,000kJ, as originally stated in the Sofia ES, to 4,000kJ, would alter the outcomes of the assessment made within the ES.

As noted previously in this document, the model used by NPL to produce result of the Sofia ES is not openly available and as a result, this stage of the assessment for marine mammals uses the same criteria as the Sofia ES, but assessed via the INSPIRE model by Subacoustech.

A summary of the noise thresholds (SEL in dB re 1µPa²s) modelled for marine mammal receptors in the Sofia ES are provided in Table 6.1.

Table 6.1 - Summary of noise thresholds (SEL in dB re 1µPa²s) modelled for marine mammal receptors.

Potential Impacts	Harbour Porpoise	White-Beaked Dolphin	Minke Whale	Grey Seal
PTS	179 ¹	198	198	186
TTS/fleeing ²	164 ¹	183	183	171
Likely avoidance ³	N/A	170	152	N/A
Possible avoidance ³	145 ¹	160	142	N/A

¹ Precautionary criteria based on single pulse in the studies by Lucke *et al.* (2009);

² Based on the single pulse criteria for the onset of TTS in studies by Southall *et al.* (2007).

³ Based on multiple pulse severity scaling in the study by Southall *et al.* (2007) – only applicable to MF and LF cetaceans.

To estimate the number of individuals that would be expected to display disturbance reactions, contours based on thresholds outlined in Table 6.1 were generated and used to work out the area of likely and potential disturbance for each species. The result was then compared with the results from the ES assessment to determine the proportion of the reference population impacted and therefore whether there was any alteration in impact level from the ES assessment. Reference population numbers were based on those used in the Sofia ES and are presented in Table 6.2.

Table 6.2 - Reference populations used in assessment. Source: Sofia ES Chapter 14.

Species	Reference population extent	Year of estimate and data source	Reference population size used in assessment (confidence intervals)
Harbour Porpoise	North Sea Management Unit	2005 (IAMMWG, 2013 based on SCANS II Hammond <i>et al.</i> 2013)	227,298 (176,360 – 292,948)
Minke Whale	(a) British Irish Management Unit (b) Central and north east Atlantic	(a) 2005 & 2007 (IAMMWG, 2013 based on SCANS II (Hammond <i>et al.</i> 2013) CODA (Hammond <i>et al.</i> 2009) (b) 1996-2001 IWC	(a) 23,168 (13,772 – 38,958) (b) 174,000 (125,000- 245,000)
White-Beaked Dolphin	British Irish Management Unit	2005 (IAMMWG, 2013 based on SCANS II Hammond <i>et al.</i> 2013)	15,895 (9,107 – 27,743)

Species	Reference population extent	Year of estimate and data source	Reference population size used in assessment (confidence intervals)
Grey Seal	North Sea (South-east England, North east England and Scottish East coast MU + Waddensea)	2007, 2008, 2010, 2011 and 2012 UK North Sea (IAMMWG, 2013) & Mainland Europe (Waddensea Secretariat)	24,950 + 4,039 = 28,989

The results presented in this section summarise the assessment of the predicted noise impact risk ranges based on the updated noise modelling for a 4,000kJ hammer energy. The potential impacts on marine mammals for the 4,000kJ hammer energy are assessed using the same densities and reference populations as the original assessment in the Sofia ES. This allows for a like for like assessment of the potential impact of the new hammer energy. For cetaceans, reference populations are based on abundance estimates from SCANS II. It is important to note that since the assessment undertaken in the Sofia ES, SCANS III³ abundance estimates for cetaceans have been published. Although the reference population used in the Sofia ES are not directly comparable to the SCANS III populations, the overall populations of both harbour porpoise and white-beaked dolphin have increased since the SCANS II survey. As a result, the higher numbers, if considered, would effectively reduce the proportional impact on these species. The original assessment included the German and Dutch Waddensea grey seal population as part of the total reference population, recognising that there is movement between the east coast of the UK and the Waddensea. However, because the surveys are not carried out at the same time of year, (UK grey seal counts are made during the August harbour seal moult, and Waddensea surveys take place in March-April) there is the possibility that there is some double counting of individuals or that there are ‘missed’ individuals counted in neither survey. However, large increases have been reported in both UK and Waddensea grey seal populations since the original assessment and as noted above for cetaceans, an assessment against updated figures would reduce the proportional impact on these species.

The results of the like for like assessment of the new hammer energy are then compared to the original values presented in the Sofia ES and reference populations for the 3,000kJ hammer energy. Tables 6.3-6.15 provide a summary of predicted disturbance ranges provided in the ES and resulting from the updated noise modelling for each receptor.

Within the assessment a soft-start procedure was considered as built in mitigation to avoid auditory injury to marine mammals. As described in the ES, a soft-start would be conducted for 30 minutes where the hammer energy applied would be around 10% of maximum hammer energy (in the ES a starting hammer energy of 300kJ was assessed for maximum hammer energy of 3,000kJ) for all piling locations. Following the soft-start, there would be a gradual increase in hammer energy, up to a maximum of full hammer energy needed to install monopoles to full design penetration at the site.

6.3.1 High-frequency Cetaceans – Harbour Porpoise

6.3.1.1 Instantaneous PTS single strike

According to the Sofia ES, NPL modelling of PTS unweighted (pulse SEL 179 dB re 1 $\mu\text{Pa}^2\text{s}$) response based on criteria from Lucke *et al.* (2009) for a hammer energy of 3,000kJ resulted in an impact risk range of <700m. Using the same criteria, but modelled with the INSPIRE model, a 3,000kJ hammer energy results in a maximum impact risk range of 700m. Using the

³ <https://synergy.st-andrews.ac.uk/scans3/files/2017/05/SCANS-III-design-based-estimates-2017-05-12-final-revised.pdf>

same modelling approach and criteria, a 4,000kJ hammer energy is predicted to result in maximum impact risk range of 850m. The impact risk ranges for PTS are shown in Table 6.3 below, along with the change from the NPL modelling in the Sofia ES for the increased hammer energy.

Table 6.3 - PTS: INSPIRE impact risk ranges for harbour porpoise.

Hammer Energy	INSPIRE - PTS unweighted (pulse SEL 179 dB re 1 $\mu\text{Pa}^2\text{s}$) maximum range	Change from ES maximum hammer impact risk range (<700m*)
3,000kJ	700m	No change
4,000kJ	850m	+21%

*For the purposes of calculating a percentage change, the maximum range presented within the original assessment (<700m) has been equated to an actual maximum distance (i.e. 700m), which was a precautionary assumption.

Table 6.5 shows the number of individuals within each impact risk range. This is based on information presented in paragraph 4.2.39 of the ES which states an upper density of 0.716 individuals per km^2 . Despite an increase in the impact risk ranges as a result of the new hammer energy, the individuals predicted to receive PTS represent <0.001% of the reference population for a 4,000kJ hammer. The Sofia ES concluded No Impact for PTS in harbour porpoise. Based on the same assessment of significance used in the Sofia ES, the low corresponding percentage of the reference population affected means there will be no change to the original conclusion. Furthermore, the implementation of a Marine Mammal Mitigation Protocol (MMMP) with appropriate mitigation would reduce this impact risk range for harbour porpoise to negligible.

6.3.1.2 TTS

In the Sofia ES, NPL modelled the TTS (pulse SEL 164 dB re 1 $\mu\text{Pa}^2\text{s}$) of harbour porpoise and identified a maximum impact risk range of 5.5km for a hammer energy of 3,000kJ.

Using the same criteria as the Sofia ES from Lucke *et al.* (2009), the INSPIRE model showed a maximum impact risk range of 6.0km for a hammer energy of 3,000kJ. Additionally, and under the same approach, the INSPIRE model showed maximum impact risk ranges of 6.7km and 6.9km for a hammer energy of 4,000kJ. The impact risk ranges for TTS are shown in Table 6.4 below, along with the change from the NPL modelling which informed the Sofia ES, for the increased hammer energy.

Table 6.4 - TTS: INSPIRE impact risk ranges for harbour porpoise.

Hammer Energy	INSPIRE - TTS unweighted (pulse SEL 164 dB re 1 $\mu\text{Pa}^2\text{s}$) maximum range	Change from ES maximum hammer impact risk range (~5.5km*)
3,000kJ	6.0km	+9.1%
4,000kJ	6.9km	+15%

*For the purposes of calculating a percentage change, the maximum range presented within the original assessment (~5.5km) has been equated to an actual maximum distance (i.e. 5.5km), which is a precautionary assumption.

Table 6.5 shows 104 individuals are predicted to receive TTS (unweighted pulse SEL 164 dB re 1 $\mu\text{Pa}^2\text{s}$) within an impact risk range of 145 km^2 (4,000kJ). The Sofia ES predicted 53 individuals (0.03% of the population) would receive TTS within an impact range area of 82.3 km^2 . Despite the increase in impact risk ranges for the increased hammer energy, 104 individuals represent 0.05% of the reference population. The Sofia ES concluded a Negligible impact for TTS response in harbour porpoise. It can be concluded in this assessment that the low percentage of the reference population affected by the increased hammer energy means there will be no change to the original conclusion.

6.3.1.3 Potential Disturbance (Possible Avoidance)

The Sofia ES predicted that based on NPL modelling, 1,820 individuals were predicted to be disturbed using a threshold of SEL 145 dB re 1 $\mu\text{Pa}^2\text{s}$, from a maximum hammer energy of 3,000kJ. This was based on an impact area of 2,841 km^2 and resulted in a potential population impact of 0.8%.

The same criterion was used by Subacoustech in the INSPIRE model which showed a reduction in the estimated area potentially disturbed for a 3,000kJ hammer by 3.6% and resulting in an estimated 1,755 individuals or 0.77% of the reference population. The same modelling approach was used for a hammer energy of 4,000kJ which predicted 2,263 individuals. This equates to 0.995% of the reference population for a 4,000kJ hammer energy.

The Sofia ES concluded a Negligible impact for possible avoidance of harbour porpoise. An increase from 0.8% for the 3,000kJ hammer, to 0.995% for the 4,000kJ hammer is not considered to change the impact magnitude from the Sofia ES. Based on the same assessment of significance used in the Sofia ES, it can be concluded that based on the low corresponding percentage of the reference population affected, there will be no change to the original conclusion.

Table 6.5 - Harbour porpoise impact risk range area and population impacts

High-Frequency Cetaceans (Harbour Porpoise)		3,000kJ hammer energy	4,000kJ hammer energy
INSPIRE - Instantaneous injury/PTS (pulse SEL 179 dB re 1 $\mu\text{Pa}^2\text{s}$) ¹	Area	1.5km ²	2.2km ²
	Individuals	0.961	1.575
	% of ref population	<0.001	<0.001
INSPIRE - TTS/fleeing response (pulse SEL 164 dB re 1 $\mu\text{Pa}^2\text{s}$) ¹	Area	108km ²	145km ²
	Individuals	69.180	104
	% of ref population	0.030	0.046
NPL - Behavioural response unweighted (pulse SEL 145 dB re 1 $\mu\text{Pa}^2\text{s}$)	Area	2,841km ²	-
	Individuals	1,820	-
	% of ref population	0.8	-
INSPIRE - Possible avoidance of area (pulse SEL 145 re 1 $\mu\text{Pa}^2\text{s}$)	Area	2,740km ²	3,160km ²
	Individuals	1,755.13	2,262.6
	% of ref population	0.772	0.996

¹No equivalent given in Sofia ES.

6.3.2 Mid-frequency Cetaceans – White-beaked Dolphin

6.3.2.1 Instantaneous PTS single strike

The NPL modelling which informed the Sofia ES, used the PTS M-weighted threshold ($\text{SEL}_{\text{ss}} M_{\text{mf}}$ 198 dB re 1 $\mu\text{Pa}^2\text{s}$) from Southall *et al.* (2007) to predict the impact risk ranges of a 3,000kJ hammer on mid-frequency cetaceans (white-beaked dolphin). NPL found that for the maximum hammer energy of 3,000kJ an impact risk range of <100m was predicted.

Under the same criteria, but modelled with the INSPIRE software, a 3,000kJ hammer energy results in a lower impact risk range of <50m. The same impact risk range of <50m was predicted using INSPIRE for a hammer energy of 4,000kJ. The impact risk ranges for PTS are shown in Table 6.6 below, along with the change from the NPL modelling in the Sofia ES for the increased hammer energy.

Table 6.6 - PTS: INSPIRE impact risk ranges for white-beaked dolphin.

Hammer Energy	INSPIRE - Instantaneous injury/PTS ($M_{\text{mf}} \text{SEL}_{\text{ss}}$ 198 dB re 1 $\mu\text{Pa}^2\text{s}$) maximum range	Change from ES maximum hammer impact risk range (<100m*)
3,000kJ	<50m	-50%

Hammer Energy	INSPIRE - Instantaneous injury/PTS (M_{mf} SEL _{ss} 198 dB re 1 μ Pa ² s) maximum range	Change from ES maximum hammer impact risk range (<100m*)
4,000kJ	<50m	-50%

*For the purposes of calculating a percentage change, the maximum range presented within the original assessment (<100m) has been equated to an actual maximum distance (i.e. 100m), which was a precautionary assumption. The same approach is applied to the INSPIRE outputs.

As shown in Table 6.8, with a density of 0.015km² (as cited at paragraph 4.2.62 of the Marine Mammal chapter of the ES), 0.001 white-beaked dolphins are predicted to be impacted by PTS when considering the 4,000kJ hammer energy. This number represents <0.001% of the reference population for the species. Additionally, impact risk ranges are well within the 500m mitigation zone implemented via the MMMP. The Sofia ES concluded No Impact from for lethal/ injury and auditory injury (PTS) for the species. Based on the reduced impact risk range predicted by INSPIRE it can be concluded there will be no change to the original conclusion.

6.3.2.2 TTS/fleeing response

NPL modelled the TTS weighted (SEL_{ss} M_{mf} 183 dB re 1 μ Pa²s) for mid-frequency cetaceans and found an impact risk range of <200m for a hammer energy of 3,000kJ.

Using the same criteria as the Sofia ES from Southall *et al.* (2007), the INSPIRE model showed a reduced maximum impact risk range of 140m for a hammer energy of 3,000kJ. Additionally, and under the same approach, the INSPIRE model showed maximum impact risk range of 160m for a 4,000kJ hammer energy. The results of the INSPIRE modelling show that an increase to a maximum hammer energy of 4,000kJ will result in the same impact risk ranges that were originally modelled in the Sofia ES for a 3,000kJ hammer energy. The impact risk ranges for TTS/fleeing response are shown in Table 6.7 below, along with the change from the NPL modelling in the Sofia ES for each hammer energy.

Table 6.7 - TTS/fleeing response: INSPIRE impact risk ranges for white-beaked dolphin.

Hammer Energy	INSPIRE - TTS/fleeing response (M_{mf} SEL _{ss} 183 dB re 1 μ Pa ² s) maximum range	Change from ES maximum hammer impact risk range (<200m*)
3,000kJ	140m	-30%
4,000kJ	160m	-20%

*For the purposes of calculating a percentage change, the maximum range presented within the original assessment (<200m) has been equated to an actual maximum distance (i.e. 200m), which was a precautionary assumption. The same approach is applied to the INSPIRE outputs.

Table 6.8 shows that the number of white-beaked dolphins and the percentage of the population they represent is the same at for TTS/ fleeing response and for PTS. As identified for PTS, impact risk ranges are well within the 500m mitigation zone implemented via the MMMP. Therefore, there will be no change to the original conclusion in the Sofia ES of No Impact.

6.3.2.3 Potential Disturbance

The Sofia ES showed that NPL modelling estimated that <1-3 individuals (for a potential impact risk area of 15-200km² respectively) were predicted to be disturbed by receiving noise levels at or above the threshold of unweighted pulse SEL 170-160 dB re 1 μ Pa²s from a maximum hammer energy of 3,000kJ. <1-3 individuals corresponded to <0.01% of the ES reference population. The same criterion was used by Subacoustech in the INSPIRE model which, for a hammer of 3,000kJ, estimated between <1 and 4 individuals which corresponds to <0.1% of the reference population respectively (Table 6.8). The same modelling approach was used for the new hammer energy which predicted a range of <1-5 individuals for a 4,000kJ hammer. This equates to <0.1% of the reference population.

The maximum increase in the potential population effected is 0.031% for the maximum 4,000kJ hammer and is not considered to change the impact magnitude from the Sofia ES. The Sofia ES concluded a Negligible impact for avoidance of white-beaked dolphin. Based on the same assessment of significance used in the Sofia ES, it can be concluded that the low corresponding percentage of the reference population affected, there will be no change to the original conclusion.

Table 6.8 – White-beaked dolphin impact risk range area and population impacts

Mid-Frequency Cetaceans (White-Beaked Dolphin)		3,000kJ hammer energy	4,000kJ hammer energy
INSPIRE - Instantaneous injury/PTS (M _{mif} SEL _{ss} 198 dB re 1 µPa ² s) ¹	Area	<0.1km ²	<0.1km ²
	Individuals	0.001	0.001
	% of ref population	<0.001	<0.001
INSPIRE - TTS/fleeing response (M _{mif} SEL _{ss} 183 dB re 1 µPa ² s) ¹	Area	<0.1km ²	0.1km ²
	Individuals	<0.001	0.001
	% of ref population	<0.001	0.001
NPL - Behavioural response unweighted (pulse SEL 170-160 dB re 1 µPa ² s)	Area	15-200km ²	-
	Individuals	0.223-2.974	-
	% of ref population	0.001-0.019	-
INSPIRE - Possible avoidance of area (pulse SEL 160-170 re 1 µPa ² s)	Area	22.5-264km ²	31.8-339km ²
	Individuals	0.335-3.926	0.477-5.085
	% of ref population	0.002-0.025	0.003-0.031

¹No equivalent given in Sofia ES.

6.3.3 Low-frequency Cetaceans – Minke Whale

6.3.3.1 Instantaneous PTS single strike

According to the Sofia ES, NPL modelling of PTS weighted (SEL_{ss} M_{if} 198 dB re 1 µPa²s) from Southall *et al.* (2007) for a hammer energy of 3,000kJ resulted in an impact risk range of <100m. Again, it is worth mentioning that this reduction is likely to be a product of model resolution between NPL and Subacoustech approaches.

Under the same criteria, but modelled with the INSPIRE model, a 3,000kJ hammer energy results in an impact risk range of <50m. Using the same approach, a 4,000kJ hammer energy results in maximum impact risk ranges of 50m. The results of the INSPIRE modelling show that an increase to a maximum hammer energy of 4,000kJ will be less (or certainly no greater) than that originally modelled in the Sofia ES for a 3,000kJ hammer energy. The impact risk ranges for PTS are shown in Table 6.9 below, along with the change from the NPL modelling in the Sofia ES for each hammer energy.

Table 6.9 - PTS: INSPIRE impact risk ranges for minke whale.

Hammer Energy	INSPIRE - Instantaneous injury/PTS (M _{if} SEL _{ss} 198 dB re 1 µPa ² s) maximum range	Change from ES maximum hammer impact risk range (<100m*)
3,000kJ	<50m	-50%
4,000kJ	50m	-50%

*For the purposes of calculating a percentage change, the maximum range presented within the original assessment (<100m) has been equated to an actual maximum distance (i.e. 100m), which is a precautionary assumption. The same approach is applied to the INSPIRE outputs.

The ES identified densities of 0.009 individuals per km² for minke whale; as shown in Table 6.11, the subsequent potential population impact of minke whales impacted by PTS for a 4,000kJ hammer energy is extremely small relative to the reference populations for the species (<0.001%). Additionally, impact risk ranges are well within the 500m mitigation

zone implemented via the MMMP. The Sofia ES concluded No Impact from for lethal/ injury and auditory injury (PTS) for the species. Based on the results of the INSPIRE modelling it can be concluded there will be no change to the original conclusion.

6.3.3.2 TTS/fleeing response

NPL modelled the TTS weighted ($SEL_{ss} M_{lf} 183 \text{ dB re } 1 \mu\text{Pa}^2\text{s}$) response of low-frequency cetacean and found an impact risk range of <400m for a hammer energy of 3,000kJ.

Using the same criteria as the Sofia ES from Southall *et al.* (2007), the INSPIRE model showed a maximum impact risk range of 380m for a hammer energy of 3,000kJ. Additionally, and under the same approach, the INSPIRE model showed maximum impact risk range of 460m for a hammer energy of 4,000kJ. The impact risk ranges for TTS/fleeing response are shown in Table 6.10 below, along with the change from the NPL modelling in the Sofia ES for each hammer energy.

Table 6.10 - TTS/fleeing response: INSPIRE impact risk ranges for minke whale.

Hammer Energy	INSPIRE - TTS/fleeing response ($M_{lf} SEL_{ss} 183 \text{ dB re } 1 \mu\text{Pa}^2\text{s}$) maximum range	Change from ES maximum hammer impact risk range (<400m*)
3,000kJ	380m	-5%
4,000kJ	460m	+15

*For the purposes of calculating a percentage change, the maximum range presented within the original assessment (<400m) has been equated to an actual maximum distance (i.e. 400m), which was a precautionary assumption. The same approach is applied to the INSPIRE outputs.

Despite an increase in the impact risk ranges for the updated maximum hammer energy, Table 6.11 shows that the number of minke whales and the percentage of the population they represent are extremely low (<0.001%) and therefore, there will be no change to the original conclusion in the Sofia ES of No Impact.

6.3.3.3 Potential Disturbance

The Sofia ES showed that NPL modelling estimated between approximately 8 and 36 individuals were predicted to be disturbed by piling noise based on maximum area of possible avoidance of 4,172km² (based on unweighted pulse SEL 152-142 dB re 1 $\mu\text{Pa}^2\text{s}$). This impact corresponded to <0.1% of the Central and north east Atlantic reference population, and 0.16% of the British Irish Management Unit.

The same criterion was used by Subacoustech in the INSPIRE model which showed a reduction in the estimated maximum area potentially disturbed for a 3,000kJ hammer by 8.1% and resulting in an estimated 33 individuals. The same modelling approach was used for the new hammer energy and predicted a maximum of 39 individuals for a 4,000kJ hammer. The percentage impact on each reference population is shown in Table 6.11 below.

The Sofia ES concluded a Negligible impact for avoidance of minke whales. Based on the same assessment of significance used in the Sofia ES, it can be concluded that the low corresponding percentage of the reference population affected, there will be no change to the original conclusion.

Table 6.11 – Minke whale impact risk range area and population impacts.

Low-Frequency Cetaceans (Minke Whale)		3,000kJ hammer energy	4,000kJ hammer energy
INSPIRE - Instantaneous injury/PTS ($M_{lf} SEL_{ss} 198 \text{ dB re } 1 \mu\text{Pa}^2\text{s}$) ¹	Area	<0.1km ²	<0.1km ²
	Individuals	<0.001	<0.001
	% of ref population ²	<0.001 (<0.001)	<0.001 (<0.001)
INSPIRE - TTS/fleeing response ($M_{lf} SEL_{ss} 183 \text{ dB re } 1 \mu\text{Pa}^2\text{s}$) ¹	Area	0.4km ²	0.7km ²
	Individuals	0.003	0.006
	% of ref population ²	<0.001 (<0.001)	<0.001 (<0.001)
	Area	953-4,172km ²	-

Low-Frequency Cetaceans (Minke Whale)		3,000kJ hammer energy	4,000kJ hammer energy
NPL - Behavioural response unweighted (pulse SEL 152-142 dB re 1 $\mu\text{Pa}^2\text{s}$)	Individuals	8.253-36.13	-
	% of ref population ²	0.005-0.021 (0.036-0.156)	-
INSPIRE - Likely avoidance of area (pulse SEL 152-142 re 1 $\mu\text{Pa}^2\text{s}$)	Area	1,090-3,830km ²	1,310-4,370km ²
	Individuals	9.44-33.17	11.79-39.33
	% of ref population ²	0.005-0.019 (0.041-0.143)	0.006-0.022 (0.05-0.170)

¹No equivalent given in Sofia ES.

²British Irish Management Unit reference population in brackets.

6.3.4 Pinniped (in water) – Grey Seal

6.3.4.1 Instantaneous PTS single strike

The NPL modelling which informed the Sofia ES, used PTS weighted ($\text{SEL}_{\text{SS}} M_{\text{pw}} 186 \text{ dB re } 1 \mu\text{Pa}^2\text{s}$) from Southall *et al.* (2007) to predict the impact risk ranges of a 3,000kJ hammer on pinnipeds.

NPL modelling found that for the maximum hammer energy of 3,000kJ stated in the Sofia ES, an impact risk range of <200m was predicted. Under the same criteria, but modelled with the INSPIRE software, a 3,000kJ hammer energy results in a lower maximum impact risk range of 140m. Using the same approach, a 4,000kJ hammer energy would result in maximum impact risk range of 170m. The impact risk ranges for PTS are shown in Table 6.12 below, along with the change from the NPL modelling in the Sofia ES for each hammer energy.

Table 6.12 - PTS: INSPIRE impact risk ranges for grey seal.

Hammer Energy	INSPIRE - Instantaneous injury/PTS ($M_{\text{pw}} \text{SEL}_{\text{SS}} 186 \text{ dB re } 1 \mu\text{Pa}^2\text{s}$) maximum range	Change from ES maximum hammer impact risk range (<200*m)
3,000kJ	140m	-30%
4,000kJ	170m	-15%

*For the purposes of calculating a percentage change, the maximum range presented within the original assessment (<200m) has been equated to an actual maximum distance (i.e. 200m), which was a precautionary assumption. The same approach is applied to the INSPIRE outputs.

Grey seal densities identified within the ES (paragraph 6.1.133) were 0.23 individuals per km². Table 6.14 shows the number of individuals within each impact risk range. For grey seal, this number of individuals represents <0.001% of the reference population for the increased hammer energy. The Sofia ES concluded Minor adverse from for lethal/ injury and auditory injury (PTS) for harbour porpoise. Based on the same assessment of significance used in the Sofia ES, it can be concluded that the low corresponding percentage of the reference population affected, there will be no change to the original conclusion.

6.3.4.2 TTS/fleeing response

NPL modelled the TTS weighted ($\text{SEL}_{\text{SS}} M_{\text{pw}} 171 \text{ dB re } 1 \mu\text{Pa}^2\text{s}$) response of pinnipeds and found an impact risk range of 1.7km for a hammer energy of 3,000kJ. Using the same criteria as the Sofia ES from Southall *et al.* (2007), the INSPIRE model showed a lower impact risk range of 1.4km for a hammer energy of 3,000kJ. Additionally, and under the same approach, the INSPIRE model showed a maximum impact risk range of 1.7km for a 4,000kJ hammer. The impact risk ranges for TTS/fleeing response are shown in Table 6.13 below, along with the change from the NPL modelling in the Sofia ES for each hammer energy.

Table 6.13 - TTS/fleeing response: INSPIRE impact risk ranges for grey seal.

Hammer Energy	INSPIRE - TTS/fleeing response ($M_{p_{w}}$ SEL _{ss} 171 dB re 1 μ Pa ² s) maximum range	Change from ES maximum hammer impact risk range (~1.7 m or less*)
3,000kJ	1.4km	-17.6%
4,000kJ	1.7km	no change

*For the purposes of calculating a percentage change, the maximum range presented within the original assessment (~1.7km) has been equated to an actual maximum distance (i.e. 1.7km), which is a precautionary assumption. The same approach is applied to the INSPIRE outputs.

Table 6.14 shows 3 individuals are predicted to be found in an impact risk range area of 8.8km² (4,000kJ), which represents 0.008% of the reference population.

An increase from 0.005% for the 3,000kJ hammer, to 0.008% for the 4,000kJ hammer is not considered to change the impact magnitude from the Sofia ES. The Sofia ES concluded a Negligible impact for TTS/ fleeing response for grey seal. Based on the same assessment of significance used in the Sofia ES, it can be concluded that the low corresponding percentage of the reference population affected, there will be no change to the original conclusion.

Table 6.14 – Grey seal impact risk range area and population impacts.

Pinnipeds (Grey Seal)		3,000kJ hammer energy	4,000kJ hammer energy
INSPIRE - Instantaneous injury/PTS ($M_{p_{w}}$ SEL _{ss} 186 dB re 1 μ Pa ² s) ¹	Area	<0.1km ²	<0.1km ²
	Individuals	<0.023	<0.023
	% of ref population	<0.001	<0.001
NPL - TTS weighted ($M_{p_{w}}$ SEL _{ss} 171 dB re 1 μ Pa ² s)	Area	9km ²	-
	Individuals	2.07	-
	% of ref population	0.007	-
INSPIRE - TTS/fleeing response ($M_{p_{w}}$ SEL _{ss} 171 dB re 1 μ Pa ² s)	Area	6.1km ²	8.8km ²
	Individuals	1.403	2.02
	% of ref population	0.005	0.008

¹No equivalent given in Sofia ES.

6.3.5 Significance of impact – Stage 1

The updated modelling results demonstrate that an increase in hammer energy utilising the updated modelling software does not change the predicted impact effect significances for any species of marine mammal assessed when compared to levels predicted in the ES assessment.

The results of the updated modelling for a maximum hammer energy of 4,000kJ showed an increase in the predicted impact areas and number of individuals that could possibly be injured/disturbed for all species. However, this increase was in most cases small and did not increase the magnitude of effect for any species assessed. Furthermore, the implementation of a MMMP (including the use of ADDs) would ensure no impact risk would exceed the range of mitigation.

As outlined above, the assessment is based on 100% of individuals within the maximum predicted range of possible disturbance potentially being impacted, although this is unlikely given the size of the area. Therefore, the assessment is precautionary, based on a worst-case scenario, maximum potential risk area and with an assumption that all individuals

are potentially disturbed. As such, the significance of impact would realistically be anticipated to be lower, however to ensure that precaution is maintained within the updated assessment, the significance levels have been maintained.

Overall, no increase in the significance of any effect on marine mammal receptors is considered to arise from the increased hammer energy of 4,000kJ in comparison to that assessed in the original application.

Table 6.15 – Comparison of overall significance from Sofia ES with the updated modelling results of this assessment.

Residual Impact	Maximum Hammer Energy	Harbour Porpoise	Minke Whale	White-Beaked Dolphin	Grey Seal
Sofia ES results	3,000kJ	Negligible	Negligible	Negligible	Negligible
Results from this assessment	4,000kJ	Negligible	Negligible	Negligible	Negligible

6.4 Stage 2 – New Criteria for Marine Mammals

As stated above in Section 4, since the original modelling was undertaken for the Sofia ES by NPL, the NMFS has developed new thresholds and criteria of noise for auditory injury to marine mammals (NMFS, 2016) (Table 6.16). These updated criteria do not include new thresholds for potential disturbance and as a result, the following assessment focuses on PTS and TTS. The NMFS (2016) metrics were re-evaluated and updated guidance was published in 2018 which did not result in any changes to the thresholds or criteria compared to the 2016 metrics. Southall *et al.* (2019) was then published which provides a peer reviewed confirmation of the thresholds and criteria within the NMFS 2016 and 2018 guidance. The only changes within Southall *et al.* (2019) are nomenclature edits (for the purposes of this assessment at least), with species previously classed as “high frequency” (i.e., harbour porpoise) now classed as “very high frequency” and species previously classed as “medium frequency” (i.e., white-beaked dolphin) now classed as “high frequency”. These nomenclature changes do not reflect any changes to the hearing sensitivity spectrum of the relevant species or any other changes compared to the NMFS 2016 and 2018 guidance. Therefore, it is not necessary to undertake updated modelling in light of the publication of the NMFS (2018) guidance or Southall *et al.* (2019) paper. Furthermore, for the purposes of this assessment, the previously used nomenclature for the various species has been retained to avoid any confusion compared to the 5,500kJ submission.

Table 6.16 - Assessment criteria for marine mammals from NMFS (2016) for impulsive noise.

Impulsive Noise	TTS Criteria	PTS Criteria
Functional Group	(unweighted) SPL _{peak} dB re 1 µPa	(unweighted) SPL _{peak} dB re 1 µPa
Low-frequency Cetaceans	213	219
Medium-frequency Cetaceans	224	230
High-frequency Cetaceans	196	202
Phocid Pinnipeds	212	218

To ascertain whether this use of the new threshold criteria affect the conclusions of the Stage 1 assessment for marine mammals, a comparison of maximum outputs from the 4,000kJ hammer energies is made between the original criteria used above and the new criteria identified by NMFS (2016).

6.4.1 Predicted harbour porpoise impact risk ranges using criteria derived from NMFS (2016)

6.4.1.1 Instantaneous PTS and TTS

The impact risk ranges for PTS and TTS of harbour porpoise for a 4,000kJ hammer energy are presented in Table 6.17 and Table 6.18 below. Both tables compare the updated NMFS (2016) criteria against the previous Lucke *et al.* (2009) criteria and show the percentage change between the maximum impact risk ranges.

Table 6.17 - Harbour porpoise: Comparison in the change of PTS potential maximum impact risk range between Lucke *et al.* (2009) and NMFS (2016) criteria.

Hammer Energy	Lucke <i>et al.</i> (2009) Instantaneous injury/PTS (unweighted pulse SEL 179 dB re 1 $\mu\text{Pa}^2\text{s}$)	NMFS (2016) PTS unweighted SPL_{peak} (202 re 1 μPa)	Percentage change
4,000kJ	850m	590m	-31%

Table 6.18 - Harbour porpoise: Comparison in the change of TTS potential maximum impact risk range between Lucke *et al.* (2009) and NMFS (2016) criteria.

Hammer Energy	Lucke <i>et al.</i> (2009) TTS/fleeing response (unweighted pulse SEL 164 dB re 1 $\mu\text{Pa}^2\text{s}$)	NMFS (2016) TTS unweighted SPL_{peak} (196 re 1 μPa)	Percentage change
4,000kJ	6.9km	1.3km	-81%

For the NMFS (2016) PTS SPL_{pk} criteria there was a 31% decrease in the impact risk ranges compared to those predicted by Lucke *et al.* (2009) for the new hammer. For TTS, the decrease was 81%.

As a result of this decrease in impact risk ranges for both PTS and TTS according to the NFMS (2016) criteria, the percentage of the reference population is also reduced from that predicted under the original criteria (Lucke *et al.* (2009)). Table 6.19 shows that even when assessing the increased hammer energy against the updated NMFS (2016) criteria, there is still no significant impact to harbour porpoise as a result of underwater piling at Sofia.

Table 6.19 - Comparison of impacts from Lucke *et al.* (2009) and NMFS (2016) for harbour porpoise.

High-Frequency Cetaceans (Harbour Porpoise)		4,000kJ hammer energy
NMFS (2016) PTS unweighted SPL_{peak} (202 re 1 μPa)	Area	1.1km ²
	Individuals	0.8
	% of ref population	<0.001
Lucke <i>et al.</i> (2009) Instantaneous injury/PTS (unweighted pulse SEL 179 dB re 1 $\mu\text{Pa}^2\text{s}$)	Area	2.2km ²
	Individuals	1.6
	% of ref population	<0.001
NMFS (2016) TTS unweighted SPL_{peak} (196 re 1 μPa)	Area	5.3km ²
	Individuals	3.8
	% of ref population	0.002
Lucke <i>et al.</i> (2009) TTS/fleeing response (unweighted pulse SEL 164 dB re 1 $\mu\text{Pa}^2\text{s}$)	Area	145km ²
	Individuals	104
	% of ref population	0.046

6.4.2 Predicted mid-frequency cetaceans impact risk ranges using criteria derived from NMFS (2016)

6.4.2.1 Instantaneous PTS and TTS

The impact risk ranges for PTS and TTS of white-beaked dolphin for a 4,000kJ hammer energy is presented in Table 6.20 and Table 6.21 below. Both tables compare the updated NMFS (2016) criteria against the previous Southall *et al.* (2007) and show the percentage change between the maximum impact risk ranges.

Table 6.20 – White-beaked dolphin: Comparison in the change of PTS potential maximum impact risk range between Southall *et al.* (2007) and NMFS (2016) criteria.

Hammer Energy	Southall <i>et al.</i> (2007) Instantaneous injury/PTS (M_{mf} SEL _{ss} 198 dB re 1 μ Pa ² s)	NMFS (2016) PTS unweighted SPL _{peak} (230 re 1 μ Pa)	Percentage change
4,000kJ	<50m	<50m	No change

Table 6.21 – White-beaked dolphin: Comparison in the change of TTS potential maximum impact risk range between Southall *et al.* (2007) and NMFS (2016) criteria.

Hammer Energy	Southall <i>et al.</i> (2007) TTS/fleeing response (M_{mf} SEL _{ss} 183 dB re 1 μ Pa ² s)	NMFS (2016) TTS unweighted SPL _{peak} (224 re 1 μ Pa)	Percentage change
4,000kJ	160m	<50m	-69%

For the NMFS (2016) PTS criteria there was no difference in the impact risk ranges from those predicted by Southall *et al.* (2007) for either hammer energy. For TTS/fleeing, there was a large decrease for a maximum hammer energy of 4,000kJ. The number of individuals associated with the PTS and TTS/fleeing response ranges above are identified in the table below, along with the consequent potential percentage of the population affected.

As a result of this decrease in impact risk ranges for both PTS and TTS/fleeing response according to the NFMS (2016) criteria, the percentage of the reference population is also reduced from that predicted under the original criteria (Southall *et al.* 2007)). Table 6.22 shows that even when assessing the increased hammer energies against the updated NMFS (2016) criteria, there is still no significant impact to white-beaked dolphin as a result of underwater piling at Sofia.

Table 6.22 - Comparison of impacts from Southall *et al.* (2007) and NMFS (2016) for white-beaked dolphin.

Mid-Frequency Cetaceans (White-beaked Dolphin)		5,500kJ hammer energy
NMFS (2016) PTS unweighted SPL _{peak} (230 re 1 μ Pa)	Area	<0.1km ²
	Individuals	<0.001
	% of ref population	<0.001
Southall <i>et al.</i> (2007) Instantaneous injury/PTS (M_{mf} SEL _{ss} 198 dB re 1 μ Pa ² s)	Area	<0.1km ²
	Individuals	<0.001
	% of ref population	<0.001
NMFS (2016) TTS unweighted SPL _{peak} (224 re 1 μ Pa)	Area	<0.1km ²
	Individuals	<0.001
	% of ref population	<0.001
Southall <i>et al.</i> (2007) TTS/fleeing response (M_{mf} SEL _{ss} 183 dB re 1 μ Pa ² s)	Area	<0.1km ²
	Individuals	<0.001
	% of ref population	<0.001

6.4.3 Predicted low-frequency cetacean impact risk ranges using criteria derived from NMFS (2016)

6.4.3.1 Instantaneous PTS and TTS

The impact risk ranges for PTS and TTS of minke whale for a 4,000kJ hammer energy is presented in Table 6.23 and Table 6.24 below. Both tables compare the updated NMFS (2016) criteria against the previous Southall *et al.* (2007) and show the percentage change between the maximum impact risk ranges.

Table 6.23 - Minke whale: Comparison in the change of PTS potential maximum impact risk range between Southall *et al.* (2007) and NMFS (2016) criteria.

Hammer Energy	Southall et al (2007) Instantaneous injury/PTS ($M_{if} SEL_{ss}$ 198 dB re 1 μPa^2s)	NMFS (2016) PTS unweighted SPL_{peak} (219 re 1 μPa)	Percentage change
4,000kJ	50m	70m	+40%

Table 6.24 – Minke whale: Comparison in the change of TTS potential maximum impact risk range between Southall *et al.* (2007) and NMFS (2016) criteria.

Hammer Energy	Southall et al (2007) TTS/fleeing response ($M_{if} SEL_{ss}$ 183 dB re 1 μPa^2s)	NMFS (2016) TTS unweighted SPL_{peak} (213 re 1 μPa)	Percentage change
4,000kJ	460m	140m	-70%

For the NMFS (2016) PTS criteria there was a 40% increase in the impact risk ranges from those predicted by Southall *et al.* (2007) for both hammer energies, although both values remain below 100m. For TTS, there was a decrease of 70% for a maximum hammer energy of 4,000kJ. The number of individuals associated with the PTS and TTS ranges above are identified in below, along with the consequent potential percentage of the population affected.

Despite an increase in impact risk ranges for PTS, the potential number of individuals affected are still significantly below the level at which anything other than a negligible impact would be concluded. For TTS according to the NFMS (2016) criteria, the percentage of the reference population is reduced from that predicted under the original criteria (Southall *et al.* 2007)). Table 6.25 shows that even when assessing the increased hammer energies against the updated NMFS (2016) criteria, there is still no significant impact to minke whale as a result of underwater piling at Sofia.

Table 6.25 - Comparison of impacts from Southall *et al.* (2007) and NMFS (2016) for minke whale.

Low-Frequency Cetaceans (Minke Whale)		5,500kJ hammer energy
NMFS (2016) PTS unweighted SPL_{peak} (219 re 1 μPa)	Area	<0.1km ²
	Individuals	<0.001
	% of ref population *	<0.001 (<0.001)
Southall <i>et al.</i> (2007) Instantaneous injury/PTS ($M_{if} SEL_{ss}$ 198 dB re 1 μPa^2s)	Area	< 0.1km ²
	Individuals	<0.001
	% of ref population *	<0.001 (<0.001)
NMFS (2016) TTS unweighted SPL_{peak} (213 re 1 μPa)	Area	<0.1km ²
	Individuals	<0.001
	% of ref population *	<0.001 (<0.001)
Southall <i>et al.</i> (2007) TTS/fleeing response ($M_{if} SEL_{ss}$ 183 dB re 1 μPa^2s)	Area	0.7km ²
	Individuals	0.006
	% of ref population *	<0.001 (<0.001)

*British Irish Management Unit reference population in brackets.

6.4.4 Predicted pinnipeds (in water) impact risk ranges using criteria from NMFS (2016)

6.4.4.1 Instantaneous PTS and TTS

The impact risk ranges for PTS and TTS of grey seal for a 4,000kJ hammer energy is presented in Table 6.26 and Table 6.27 below. Both tables compare the updated NMFS (2016) criteria against the previous Southall *et al.* (2007) and show the percentage change between the maximum impact risk ranges.

Table 6.26 – Grey seal: Comparison in the change of PTS potential maximum impact risk range between Southall *et al.* (2007) and NMFS (2016) criteria.

Hammer Energy	Southall <i>et al.</i> (2007) Instantaneous injury/PTS ($M_{pw} SEL_{ss}$ 186 dB re 1 μPa^2s)	NMFS (2016) PTS unweighted SPL_{peak} (218 re 1 μPa)	Average percentage change
4,000kJ	170m	80m	-53%

Table 6.27 – Grey seal: Comparison in the change of TTS potential maximum impact risk range between Southall *et al.* (2007) and NMFS (2016) criteria.

Hammer Energy	Southall <i>et al.</i> (2007) TTS/fleeing response ($M_{pw} SEL_{ss}$ 171 dB re 1 μPa^2s)	NMFS (2016) TTS unweighted SPL_{peak} (212 re 1 μPa)	Average percentage change
4,000kJ	1.7km	160m	-91%

For the NMFS (2016) PTS criteria there was a decrease in the impact risk ranges from those predicted by Southall *et al.* (2007), for the increased hammer energy (53%). For TTS, there was a decrease of 91% for a maximum hammer energy of 4,000kJ. The number of individuals associated with the PTS and TTS ranges above are identified in below, along with the consequent potential percentage of the population affected.

There was a decrease in impact risk ranges for both PTS and TTS according to the NFMS (2016) criteria, the percentage of the reference population is also reduced from that predicted under the original criteria (Southall *et al.* 2007)). Table 6.28 shows that even when assessing the increased hammer energy against the updated NMFS (2016) criteria, there is still no significant impact to grey seal as a result of underwater piling at Sofia.

Table 6.28 - Comparison of impacts from Southall *et al.* (2007) and NMFS (2016) for grey seal

Pinnipeds (Grey Seal)		4,000kJ hammer energy
NMFS (2016) PTS unweighted SPL_{peak} (218 re 1 μPa)	Area	<0.1km ²
	Individuals	0.023
	% of ref population	<0.001
Southall <i>et al.</i> (2007) Instantaneous injury/PTS ($M_{pw} SEL_{ss}$ 186 dB re 1 μPa^2s)	Area	<0.1km ²
	Individuals	0.023
	% of ref population	<0.001
NMFS (2016) TTS unweighted SPL_{peak} (212 re 1 μPa)	Area	<0.1km ²
	Individuals	0.023
	% of ref population	<0.001
Southall <i>et al.</i> (2007) TTS/fleeing response ($M_{pw} SEL_{ss}$ 171 dB re 1 μPa^2s)	Area	8.8km ²
	Individuals	2.024
	% of ref population	0.008

6.4.5 Stage 2 (Updated criteria) assessment summary

Overall, no increase in the significance of any effect on marine mammal receptors is considered to arise from the use of the larger 4,000kJ hammer for monopoles in comparison to that assessed in the original application (3000kJ). There are some increases evident in terms of areas affected at relevant thresholds for minke whale, however the proportions of the populations potentially subject to noise exposure remain small and ensures that no exceedance of the original ES significance findings would occur. Furthermore, the implementation of a MMMP with a standard 500m mitigation zone would reduce this impact risk range for those receptors which exceed 500m.

6.4.6 Summary of marine mammal assessment

Therefore, based on the information presented above in Stage 1 and Stage 2 for a 4,000kJ hammer energy for the monopoles, the significance of the potential impacts remains as stated in the ES, and are as follows:

Residual Impact	Harbour Porpoise	Minke Whale	White-Beaked Dolphin	Grey Seal
Overall impact	Negligible	Negligible	Negligible	Negligible

This environmental assessment compares the environmental topics and the potential effects and impacts that were identified within the Sofia ES with the increase proposed to the maximum hammer energy for monopole foundation installation. Consideration has been given to the effects of the proposed changes and whether these changes could result in impacts of significance (in EIA terms) or greater significance to those identified in the existing assessment as submitted to the Secretary of State in 2015 and consented in 2015.

Section 6.3.5 concludes that the potential impacts in relation to marine mammals associated with the proposed changes to increase the maximum hammer energy for monopole foundations are of no greater significance than those identified in the original Sofia ES.

6.4.7 Consideration of SELcum

As identified in Section 2 of this Environmental Appraisal during the consultation on the original 5,500kJ hammer energy increase proposal a request was made by stakeholders for bespoke underwater noise modelling to be undertaken to consider the impact ranges based on SEL_{cum} metrics (as detailed in the consultation included within Appendix D). Whilst SOWFL remained of the view that this was not appropriate given the nature and purpose of the work (a comparison exercise to the original assessments within the ES, noting that SEL_{cum} metrics were not considered within the ES meaning no comparison between outputs could be undertaken), such modelling was undertaken in support of the non-material amendment application submitted in June 2018. The modelling work undertaken by Subacoustech (in 2018) included modelling of 4,000kJ scenarios and these outputs remain valid for this appraisal, and are reported in Appendix B. SEL_{cum} outputs for PTS effects for high frequency cetaceans (i.e., harbour porpoise), mid frequency cetaceans (i.e., white beaked dolphin), low frequency cetaceans (i.e., minke whale) and pinnipeds (i.e., grey seal) were all shown to affect 0.005% or less of the reference populations of these species. The assessment results demonstrate that the updates to the maximum design envelope for pile driving activity at Sofia (including a hammer energy increase for the installation of monopoles) will not result in cumulative exposure to piling noise that would result in any significant impacts to marine mammal species. It can therefore be concluded that despite changes to the project design envelope for the increase in hammer energy for monopoles, and changes in assessment methodology, the predicted worst-case impacts are not greater than those presented and assessed in the original ES for the project.

It is noted (as evidenced in Tables 3.1, 3.3 and 3.7 of Appendix B) that for all groups modelled SEL_{cum} PTS impact ranges for monopoles are within standard mitigation technique ranges with the exception of low frequency cetaceans, where ranges may extend out for a number of kilometres. It is important to note that (whilst ranges do increase with an increase in hammer energy) SEL_{cum} modelling undertaken indicates that ranges would still be beyond standard mitigation technique ranges even for the currently consented hammer energies. This will therefore, be a matter that will need to be considered and addressed through the MMMP process prior to the commencement of works. It does not influence the findings or conclusions drawn within this report.

6.4.8 Consideration of effects on fish

As identified in Section 2 of this Environmental Appraisal during the consultation on the original 5,500kJ hammer energy increase proposal a request was made by the MMO and CEFAS for bespoke underwater noise modelling to be undertaken to consider the impacts of the increased hammer energy on fish receptors (as detailed in Appendix C). SOWFL (and Natural England) remained of the view that this was not appropriate given the agreements reached during the examination phase of the consent application that duration, not hammer energy, was the driving factor in selecting the worst case scenario. Nonetheless, bespoke modelling work was undertaken by Subacoustech in 2018, which included modelling of 4,000kJ scenarios and these outputs remain valid for this appraisal, and are reported in Appendix C. Further modelling of potential for impacts on the Flamborough Head herring spawning ground (using a static receptor model) was then also undertaken in an effort to reach agreement with the MMO and CEFAS on the conclusions of the 5,500kJ hammer energy increase report in 2018. This only comprised modelling of the 5,500kJ scenario and not the 4,000kJ scenario. Whilst all of the points raised by SOWFL during this consultation about the overly precautionary natures of such modelling, new modelling to capture the 4,000kJ scenario has been undertaken in support of this Environmental Appraisal (in anticipation of the same queries being raised by the MMO). The detail of the fish modelling for 4,000kJ is presented at Appendix C of this report.

The assessment of cumulative sound exposure (as detailed in Appendix C) has identified that:

For lethal / injurious effects, whilst for some outputs the maximum range may increase as a result of the increase to a maximum hammer energy of 4,000kJ, the effects remain very much within the localised area and therefore, the rationale for the conclusion reached within the ES remains valid.

For behavioural effects the updated ranges predicted for a 4,000kJ hammer energy scenario are within those ranges predicted within the ES (see Table 4.1 above) that underpinned the subsequent impact assessment. Furthermore, it has been identified that under the 4,000kJ hammer energy scenario (to which this report relates), the duration of effect will be reduced by 185% from that considered within the ES (where pin piles were identified as the worst case scenario based on the longer duration of noise exposure).

As a result of these findings, the significance of these impacts will be no greater than that concluded within the original ES, when a 4,000kJ maximum hammer energy is applied for monopole foundations.

As noted above, further bespoke modelling has been undertaken to explore potential impacts on the Flamborough Head herring spawning grounds for the 4,000kJ hammer energy. All modelling outputs have demonstrated that there will not be any behavioural effects on the spawning ground as a result of the use of a maximum hammer energy of 4,000kJ.

7 Consideration of The Habitats Regulations

Consideration has also been given to the potential consequence of the proposed increase in hammer energy on any features of European designated sites. As established within the Appropriate Assessment (AA) carried out by the Secretary of State for the Project (DECC, 2015), underwater noise from piling operations was identified as having the potential to interact with designated features from a range of European sites either directly or indirectly. Those features where direct effects were considered included harbour porpoise and grey seal. Those features where indirect effects were considered comprised a range of seabird species, with the indirect effect being related to the potential reduction in prey resource (fish) as a result of underwater noise impacts on these species.

The assessment for the hammer energy increase has identified that the worst case assumptions for underwater noise impacts on fish receptors has not changed (as it related to jacket foundation solutions). Therefore, the conclusions reached within DECC, 2015 that there would be no AEoI on any ornithological feature of a designated site from underwater noise effects on prey resource, remain valid.

For grey seal the AA identified that no AEoI would occur due to the extremely small effect at population scale on the species (when considering PTS effects) and that displacements effects would equally be tolerable given the extensive foraging ranges. The assessment for hammer energy increase has identified that the increase in hammer energy would not result in a change to the predictions made within the original ES for either PTS or displacement effects and therefore, the conclusions drawn by DECC in the AA would remain valid.

The DECC AA for Sofia made recognition of the fact that a designated site had been brought forward for harbour porpoise following the consent application. Whilst consideration was given at a high level within the DECC AA to this site (the southern North Sea draft Special Area of Conservation) there was limited conservation advice available at that time. A conclusion of no AEoI was reached based on the requirement for the Applicant to follow the JNCC 2010 guidelines and that these were sufficient mitigation measures for harbour porpoise. Since 2015, the site has progressed, with conservation advice released and the site now having been adopted as a full SAC. SOWFL note that BEIS are undertaking a review of consents (RoC) process for all projects which may impact on the Southern North Sea (SNS) Special Area of Conservation (SAC), however this has not yet been published as final. A draft version of the Habitats Regulation Assessment (HRA) to support the RoC was published (December 2018⁴) for comment and this identified that with the implementation of a Site Integrity Plan (SIP) by all projects, it would be concluded that there would be no AEoI on the SNS SAC from construction alone or in-combination for all projects. SOWFL can confirm that it has an extant commitment within the DML conditions for the preparation of the MMMP, to undertake an updated Report to Inform Appropriate Assessment (RIAA) for the specific project alone and in-combination to demonstrate that an AEoI on the SNS SAC will be avoided as part of its pre-commencement requirements. The following paragraphs give consideration to the potential hammer energy increase on this site based on the latest conservation objective information and guidance for undertaking the assessment. The information provided below comprises the primary information which would be included in the RIAA element of any SIP which is likely to be required prior to the construction of Sofia.

Sofia falls partially within the SNS SAC (Figure 1). The SNS SAC is designated solely for harbour porpoise, a species known to be sensitive to underwater noise such as that resulting from percussive piling. As part of the assessment for the increase in hammer energy, the potential implications for the conservation objectives of the SNS SAC have been considered here.

As part of the assessment of the proposed increase in hammer energy, consideration is given here to the potential for such an increase to change the existing conclusion of no AEoI made by DECC in 2015. To do so, consideration of the sites Conservation Objectives is required⁵. The Conservation Objectives are set out below.

To avoid deterioration of the habitats of the harbour porpoise or significant disturbance to the harbour porpoise, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to maintaining Favourable Conservation Status (FCS) for the UK harbour porpoise.

To ensure for harbour porpoise that, subject to natural change, the following attributes are maintained or restored in the long term:

1. The species is a viable component of the site.
2. There is no significant disturbance of the species.
3. The supporting habitats and processes relevant to harbour porpoises and their prey are maintained.

The following text considers the potential effect of the proposed hammer energy increase on each of these Conservation Objectives.

7.1.1.1 The Species is a Viable Component of the Site

Harbour porpoise are considered to be a viable component of the site if they are able to survive and live successfully within it. The intent of this objective is to minimise the risk posed by activities within the site to the species viability, specifically activities that kill, injure or significantly disturb harbour porpoise.

The measure of viability is typically considered through determination of the potential for an activity to result in death or injury of an individual – with permanent threshold shift (PTS) included within this category. The additional modelling undertaken for the increase in hammer energy includes consideration of the risk of PTS for harbour porpoise. The report

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https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/753026/RoC_SNS_cSAC_HRA_5.0.pdf

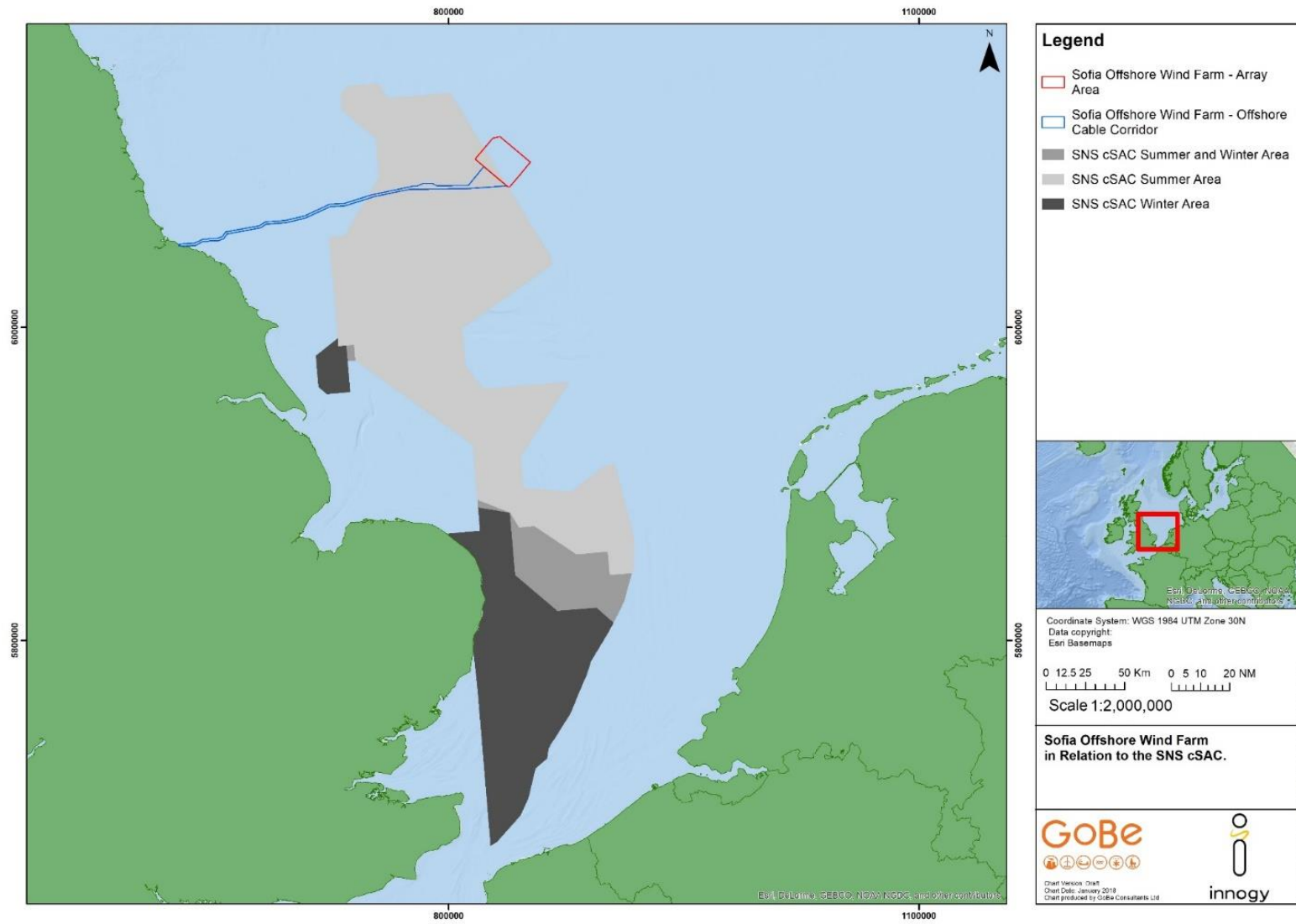
⁵ <http://jncc.defra.gov.uk/pdf/SouthernNorthSeaConservationObjectivesAndAdviceOnActivities.pdf>

includes a number of calculations, to enable both a comparison with the existing assessment and the increase in hammer energy but also to take account of the NOAA/Southall *et al.* criteria (NMFS, 2016, 2018 and Southall *et al.*, 2019). The ranges modelled for high frequency cetaceans (including harbour porpoise), for PTS only and applying the NOAA criteria, are given below.

High-frequency cetaceans - impact criterion		4,000 kJ hammer energy
PTS unweighted SPL _{peak} (202 re 1 µPa)	Maximum	590m
	Minimum	580m
	Mean	590m
	Area	1.1km ²
PTS weighted SEL _{cum} (155 dB re 1 µPa2s)	Maximum	250m
	Minimum	190m
	Mean	220m
	Area	0.2km ²

It is clear from the ranges provided above that the risk of PTS (considering either SEL_{peak} or SEL_{cum} metrics) with the increase in hammer energy remains well within the standard MMMP mitigation range (with such mitigation comprising standard industry best practice techniques such as Marine Mammal Observers, Passive Acoustic Monitoring, Acoustic Deterrent Devices and a soft start to piling). The increase in hammer energy would therefore not change the existing conclusion of no AEoI with respect to the first conservation objective for either the Project alone or in-combination with other plans, projects or proposals. Consideration of disturbance is typically made separately, under the second conservation objective below.

Figure 1: Sofia Offshore Wind Farm and the SNS SAC.



7.1.1.2 There is no Significant Disturbance of the Species

The measure of 'significant disturbance' within the SNS SAC is made based on a standard Effective Deterrent Radius (EDR) of 26km as advocated by the Statutory Nature Conservation Bodies (SNCBs)⁶. The measure is applied irrespective to the type or size of pile being installed or the hammer energy applied, having been drawn from empirical studies during percussive piling at a number of offshore wind farm projects across Europe. The increase in hammer energy would therefore have no effect on the determination of AEoI for either the Project alone or in-combination with other plans, projects or proposals.

7.1.1.3 The Supporting Habitats and Processes Relevant to Harbour Porpoises and their Prey are Maintained

The third and final conservation objective relates to the availability of prey and the supporting habitats for both harbour porpoise and that prey. The increase in hammer energy will not result in a physical change in the habitat of harbour porpoise. The assessment has identified no change in relation to the worst case scenario assessed for fish and therefore there can be no change in the conclusions of the ES with respect to fish ecology. As a result, there can be no change in the existing conclusions of the DECC AA of no AEoI relating to this Conservation Objective, for either the Project alone or in-combination with other plans, projects or proposals.

It is noted (based on the conclusions drawn in Section 6) that there will be no significant effects on fish receptors even when considering both mobile and static fish modelling outputs, therefore, further confidence is held within this conclusion.

Shadow Habitats Regulation Assessment

In anticipation that a Habitats Regulation Assessment (HRA) may be required for the Application following correspondence from BEIS in their letter dated 29 November 2018, Appendix E to this document (separate report) provides information to support a HRA. This letter from BEIS related to a previous application for an increase in hammer energy for the project, which was subsequently withdrawn by SOWFL in February 2019. In their letter relating to the SOWFL's previous application for an increase in hammer energy, BEIS advised:

"Given the proposed reliance on mitigation measures to remove the need for an Appropriate Assessment of impacts on both marine mammals and fish, the Secretary of State is not satisfied that full account has been taken of the judgment of the Court of Justice of the European Union in Case C-323/17 People over Wind that was referred to in my letter of 2 November 2018. The Secretary of State requests that the Applicant, Natural England and MMO update the Secretary of State on whether full account had been taken of that judgment and whether the statements above need to be revised. The Secretary of State also considers it necessary to undertake an HRA to assess the materiality of the Application. The Secretary of State notes that the need for an Appropriate Assessment is not necessarily of itself determinative of whether a change should be considered material. In the circumstances, the Secretary of State requests that the Applicant provides further information (for instance, in the form of an updated shadow HRA/report to inform the HRA) to inform the decision on materiality, including the possible effects of the consent, if amended, on the Southern North Sea cSAC/SCI".

Appendix E (separate document) clarifies the effects of the Project in relation to the Southern North Sea (SNS) Special Area of Conservation (SAC; the site was adopted as a full SAC in January 2019) and the current application, by SOWFL to increase the hammer energy for monopole installation to 4,000 kJ.

⁶ E.g. see workshop outputs contained within: JNCC, 2017a. A potential approach to assessing the significance of disturbance against conservation objectives of the harbour porpoise cSACs. Discussion document version 3.0 and JNCC, 2017b. Harbour porpoise SACs noise management stakeholder workshop. Report.

8 Conclusion

Following further design studies post consent, SOWFL has been made aware that a higher hammer energy may be required in order to ensure successful monopole foundation installation.

This report presents the environmental appraisal undertaken by SOWFL for the increase in hammer energy to 4,000kJ for monopole foundations for each of the relevant ES Chapters and demonstrates that there will be no increase in effect significance compared to the assessment within the ES on any receptors as a result of the increased hammer energy.

As the current consented maximum hammer energy is specified on the face of the DCO for Sofia, an amendment to the existing consent is considered to be through the non-material change process for DCOs. The relevant guidance for identifying the nature of the DCO amendment (material/non-material) is outlined in the Department for Communities and Local Government (DCLG's) "Guidance on Changes to Development Consent Orders" (December 2015), the relevant part of which, for the purposes of this paper, comprises:

Where any new or significant effects on the environment as a result of the change mean that an update to the original Environmental Statement (from that at the time the original DCO was made) is required (to take account of those effects)

The assessment presented within this report has identified that for the relevant receptors, no change in the significance of any effect from those identified in the original ES, which supported the DCO application, arise from the use of a higher energy hammer for monopole installation at Sofia. It is therefore concluded that the increase in hammer energy, which will ensure that monopoles can be successfully installed, can be taken forward under the non-material change mechanism. The lack of any change in the significance of predicted effects, notably including assessment of impacts using updated noise effect threshold criteria, indicate that the increased hammer energy sought is acceptable on the basis that the planned construction activities will not result in any greater impacts than those determined within the ES.

Consideration has also been given to the conclusions of the DECC AA for the Project and additional detail provided in relation to the SNS SAC (whose designation process has advanced since 2015), and it is confirmed that the proposed increase in hammer energy would not alter any of the findings relating to no LSE or indeed no AEol.

Finally, given the agreed positions reached with Natural England and the MMO on the previous 5,500kJ hammer energy increase application submitted in 2018 (that it would not represent a material change), and the evidence presented here for the 4,000kJ hammer energy scenario which demonstrates that impacts ranges are reduced from the 5,500kJ scenario, it is considered that these agreements should be reinforced with an even greater level of confidence for this non-material change application.

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