East Anglia TWO Offshore Windfarm

Draft Marine Mammal Mitigation Protocol

Applicant: East Anglia TWO Limited
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Applicable to East Anglia TWO

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02	n/a	n/a	Deadline 3 update
03	n/a	n/a	Deadline 7 update
04	n/a	n/a	Deadline 8 update

Table of Contents

Glossary of Acronyms

ADD	Acoustic Deterrent Device
DCO	Development Consent Order
EIA	Environmental Impact Assessment
ELO	Environmental Liaison Officer
EOD	Explosive Ordnance Disposal
ES	Environmental Statement
JNCC	Joint Nature and Conservation Committee
kg	Kilogram
kJ	Kilojoules
km	Kilometre
km^2	Kilometre squared
LAT	Lowest Astronomical Tide
LiDAR	Light Detection and Ranging
m	Metre
m/s	Metres per second
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MMOs	Marine Mammal Observers
MW	Megawatt
NEQ	Net Explosive Quantities
NMFS	National Marine Fisheries Services
NOAA	National Oceanic and Atmospheric Administration
PAM	Passive Acoustic Monitoring
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SIP	Site Integrity Plan
SNCB	Statutory Nature Conservation Body
SPL	Sound Pressure Level
SPL_{peak}	Peak Sound Pressure Level
TWT	The Wildlife Trust
UK	United Kingdom
UXO	Unexploded Ordnance

Glossary of Terminology

Applicant	East Anglia TWO Limited.
Construction, operation and maintenance platform	A fixed structure required for construction, operation and maintenance personnel and activities.
East Anglia TWO project	The proposed project consisting of up to 75 wind turbines, up to four offshore electrical platforms, up to one construction, operation and maintenance platform, inter-array cables, platform link cables, up to one operational meteorological mast, up to two offshore export cables, fibre optic cables, landfall infrastructure, onshore cables and ducts, onshore substation, and National Grid infrastructure.
East Anglia TWO windfarm site	The offshore area within which wind turbines and offshore platforms will be located.
Inter-array cables	Offshore cables which link the wind turbines to each other and the offshore electrical platforms. These cables will include fibre-optic cables.
Landfall	The area (from Mean Low Water Springs) where the offshore export cables would make contact with land, and connect to the onshore cables.
Meteorological mast	An offshore structure which contains meteorological instruments used for wind farm data acquisition.
Monitoring buoys	Buoys to monitor *in situ* conditions within the windfarm, for example, wave and met ocean conditions.
Offshore cable corridor	This is the area which will contain the offshore export cable between offshore electrical platforms and landfall jointing bay.
Offshore development area	The East Anglia TWO windfarm site and offshore cable corridor (up to Mean High Water Springs).
Offshore electrical infrastructure	The transmission assets required to export generated electricity to shore. This includes the inter-array cables from the wind turbines to the offshore electrical platforms, offshore electrical platforms, platform link cables and export cables from the offshore electrical platform to the landfall.
Offshore electrical platform	A fixed structure located within the windfarm area, containing electrical equipment to aggregate the power from the wind turbines and convert it into a more suitable form for export to shore.
Offshore export cables	The cables which would bring electricity from the offshore electrical platforms to the landfall. These cables will include fibre optic cables.
Offshore infrastructure	All of the offshore infrastructure including wind turbines, platforms, and cables.
Offshore platform	A collective term for the offshore construction operation and maintenance platform and the offshore electrical platforms.
Mitigation Zone	The area in which mitigation will be implemented.
Monitoring Area	An area within the Mitigation Zone in which marine mammal observers conduct a visual search for marine mammals.
Platform link cable	An electrical cable which links one or more offshore platforms. These cables will include fibre optic cables.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.

1 Introduction

1.1 Changes to Previously Submitted Document

1.1.1 Deadline 8 Update

1. The updates within this document take account of comments made by Natural England and the Marine Management Organisation requesting the removal of clustering as a potential mitigation measure. As agreed with the MMO, text has been inserted to clarify the meaning of UXO detonation (see ***section 4***).

1.2 Purpose of this Document

2. The purpose of this draft MMMP is to demonstrate the principles of the final MMMP to be submitted for approval as required under the draft Development Consent Order (DCO) for the proposed East Anglia TWO project, and to detail contingency arrangements to respond to and minimise the impacts of unexploded ordnance (UXO) clearance and piling associated with the construction of the proposed East Anglia TWO project.

3. The draft DCO states that:

> *No removal or detonation of UXO can take place until the following have been submitted to and approved in writing by the MMO -*
>
> *a marine mammal mitigation protocol in accordance with the draft marine mammal mitigation protocol, the intention of which is to prevent injury to marine mammals, following current best practice as advised by the relevant statutory nature conservation bodies;*

4. The draft DCO states that:

> *The licensed activities or any part of those activities must not commence until the following (as relevant to that part) have been submitted to and approved in writing by the MMO: In the event that driven or part-driven pile foundations are proposed to be used, a marine mammal mitigation protocol in accordance with the draft marine mammal mitigation protocol, the intention of which is to prevent injury to marine mammals, following current best practice as advised by the relevant statutory nature conservation bodies.*

5. This draft MMMP is in relation to potential impacts of piling and for UXO clearance. During the pre-construction period separate MMMPs for both piling and UXO clearance will be developed for the proposed East Anglia TWO project. The final MMMPs to be developed will take account of the most suitable mitigation measures.

6. These measures will be consulted upon with the SNCBs and The Wildlife Trusts (TWT).

7. This draft MMMP for piling and UXO clearance sets out the protocol of how the proposed East Anglia TWO project would:

   - Mitigate impacts assessed in the Environmental Impact Assessment (EIA) to reduce the likelihood of injury to marine mammals as a result of underwater noise during underwater piling operations and UXO clearance; and
   - Meet the relevant licence condition as stated above.

8. The final MMMP for piling will be submitted to the MMO at least six months prior to construction, for approval in consultation with the relevant SNCBs. The final MMMP for UXO clearance will be submitted to the MMO at least six months prior to UXO clearance activities being undertaken, for approval in consultation with the relevant SNCB. East Anglia TWO Limited will follow the relevant guidelines at the time in relation to a strategic approach to construction and monitoring, and the development of the final MMMP for both piling and UXO clearance as detailed in the In-Principle Monitoring Plan (APP-590).

2 Description of the Project

9. East Anglia TWO Ltd ('the Applicant') is seeking a DCO for the proposed East Anglia TWO project, an offshore windfarm located in the southern North Sea.

10. The East Anglia TWO windfarm site will cover an area of approximately 218km^2 in the southern North Sea; approximately 33km from its nearest point to Southwold and 37km from the port of Lowestoft. Water depths within the site range from 33 to 67m (relative to the Lowest Astronomical Tide (LAT)), with water depths generally increasing in the south-east of the East Anglia TWO windfarm site.

11. Once built, the proposed East Anglia TWO project would comprise the following offshore components:

    - The offshore wind turbines and their associated foundations;
    - Scour protection around foundations as required;
    - Offshore electrical platforms supporting required electrical equipment, possibly also incorporating offshore facilities;
    - Up to one meteorological mast (met mast) and associated foundations for monitoring wind speeds during the operational phase;

- Up to one construction, operation and maintenance platform may be required to house construction, operation and maintenance personnel and equipment; and
- Subsea cables comprising inter-array, platform link and offshore export cables and associated cable protection as required.

12. The detailed design of the proposed East Anglia TWO project (e.g. numbers of wind turbines, layout configuration, foundation type and requirement for scour protection) would not be determined until post-consent. Therefore, realistic worst-case scenarios in terms of potential impacts/effects are adopted to undertake a precautionary and robust impact assessment.

13. The proposed East Anglia TWO project would consist of a maximum of 60 x 282m or 75 x 250m blade tip height wind turbines (above Lowest Astronomical Tide (LAT). Therefore, the assessments in the Environmental Statement (ES) are based on a worst case of either 60 x 282m or 75 x 250m turbines.

14. The full offshore construction window is expected to be approximately 27 months and offshore construction is anticipated to commence around 2025.

15. There is the likely requirement for UXO clearance prior to construction. Whilst any underwater UXO that are identified would preferentially be avoided, it is necessary to consider the potential for underwater UXO detonation where retrieval is deemed to be unsafe and avoidance is not possible.

16. A detailed UXO survey would be completed prior to construction. The exact number of possible detonations and duration of UXO clearance operations is therefore not known at this stage. It has been estimated, based on the UXO survey for East Anglia ONE (East Anglia ONE Limited 2018), that there could be up to approximately 80 UXO within the offshore development area.

17. It is not currently known the size or type of the UXO that could be present, therefore a range of charge sizes, based on the UXO survey for East Anglia ONE (East Anglia ONE Limited 2018), has been assessed, with the maximum charge weight of up to 700kg.

18. The maximum charge weight assumed is considered to provide a good baseline for predicting and measuring the effects of any UXO that could be encountered within the offshore development area.

2.1 Key Relevant Project Characteristics and Worst-Case Scenarios

Parameter	Characteristic
Approximate construction duration	27 months

Parameter	Characteristic
East Anglia TWO windfarm site area	218km^2
Maximum offshore cable corridor area	138km^2
East Anglia TWO windfarm site water depth range	33m to 67m (relative to the LAT)
Distance from East Anglia TWO windfarm site to shore (closest point of site to Southwold)	33km
Number of wind turbines	Up to 75
Number of other offshore platforms	Up to four electrical platforms. One construction, operation and maintenance platform. One met mast.
Wind turbine foundation type options	1 (monopile) or 4 legged jacket (pin-piles) or 4 legged jacket (suction caisson) or Suction caisson or Gravity base foundation.
Meteorological mast foundation type options	1 monopile or 4 legged jacket (pin-piles) or 4 legged jacket (suction caisson) or Suction caisson or Gravity base foundation.
Offshore platform foundation type options	8 legged jacket (pin-piles) or 8 legged jacket (suction caisson) or Monopiles or Gravity base foundation.
Number of piles per foundation	Wind turbines: 1 (monopile) or 4 legged jacket (pin-piles).

Parameter	Characteristic
	Offshore platforms: 8 legged jacket (pin-piles) or 1 monopile Met mast: 1 monopile or 4 legged jacket (pin-piles).
Maximum number of piles - Wind turbines	75 x 4 pin-piles (250m wind turbine with 4 legged jacket) = 300
Maximum number of piles - Offshore platforms	4 x offshore electrical platform with 8 piles = 32 1 x Met masts = 4 1 x construction, operation and maintenance platform = 8 Total = 44
Hammer energies	Maximum hammer energy: 2,400kJ pin-pile 4,000kJ monopile Starting hammer energies of 10% will be used followed by ramp-up.
Pile diameter	15m monopile (282m wind turbine and offshore platforms) 4.6m pin pile (282m wind turbine and offshore platforms)
Number of concurrent piling events	None
Estimated number of UXO	Up to 80*
Estimated size of UXO	Up to 700kg (net explosive quantity) *

**Indicative only – based on best available information from East Anglia ONE (East Anglia ONE Limited 2018).*

3 Background

19. The Applicant has made an assessment of potential impacts to marine mammals as part of the EIA which is reported in ***Chapter 11 Marine Mammals*** of the Environmental Statement (ES) (APP-059).

20. At a project level, the potential impacts from the proposed East Anglia TWO project, based on the worst-case scenarios of piling and UXO clearance, have been assessed for any permanent auditory injury (Permanent Threshold Shift (PTS)) in harbour porpoise, grey seal and harbour seal as a result of underwater noise from UXO clearance or piling.

21. Both UXO clearance and piling have the potential to produce underwater noise capable of causing auditory injury and disturbance to marine mammals. This draft MMMP details how the Applicant would reduce the risk of underwater noise of UXO clearance and piling from causing auditory injury to marine mammals that could be present in and around the East Anglia TWO site.

22. Whilst any underwater UXO that are identified would preferentially be avoided, it is necessary to consider the requirement for underwater UXO detonation where it is deemed unsafe to retrieve the UXO from the seafloor.

23. For UXO clearance, it has been assessed that for harbour porpoise, the largest possible UXO clearance event in the site could have a major to moderate adverse impact without mitigation, for grey seal it could have a moderate adverse impact and for harbour seal it could have a minor adverse impact, without mitigation. The final MMMP developed in the pre-construction period, where more information is available on the sizes and locations of any UXO devices present, would reduce the impact to **minor adverse** for all species.

24. For the impact of PTS from piling, it has been assessed that a single strike of the starting hammer energy, or a single strike of the maximum hammer energy (for either monopiles or pin piles), could have a minor adverse impact on harbour porpoise, grey seal and harbour seal, with or without any mitigation. Permanent auditory injury (PTS) as a result of underwater noise during piling due to cumulative exposure in harbour porpoise, grey seal and harbour seal have also been assessed as minor adverse with or without mitigation. These impacts remain as **minor adverse** with mitigation measures implemented, as outlined below.

25. In addition to the draft MMMP, an In Principle East Anglia TWO Southern North Sea (SNS) Special Area of Conservation (SAC) Site Integrity Plan (SIP) has been updated and submitted at Deadline 7: document reference 8.17). This document sets out the approach for the Applicant to deliver the required mitigation

measures for the proposed East Anglia TWO project to ensure the avoidance of Adverse Effect on Integrity to the designated features of the Southern North Sea SAC in-combination with other projects, in view of the Conservation Objectives for harbour porpoise.

4 East Anglia TWO Commitments

26. In addition to the embedded mitigation secured through this MMMP (such as establishing a Mitigation Zone based on the maximum potential range for PTS, soft-start and ramp-up, and activation of ADDs prior to soft-start, see ***section 5***), the Applicant made several mitigation commitments within the Application. Following discussions with Natural England and the MMO, these commitments which were originally included in the draft MMMP (APP-594 and REP3-045), In-Principle SIP (APP-591 and REP3-043) and ES ***Chapter 11 Marine Mammals*** (AS-059) have now been secured within a new condition within the updated draft DCO submitted at Deadline 7 and Deadline 8.

27. Condition 28 of the Generation DML and Condition 24 of the Transmission DML now prevents concurrent piling, concurrent UXO detonations or a combination of the two, and restricts the number of noisy events to one within a 24 hour period during the SNS SAC winter period.

28. In the context of the condition, UXO detonation is intended to mean detonation of a single UXO and not detonation of a cluster of UXO purposefully placed together. However, where two or more UXO are found lying next to one another at a proximity where there is a risk that detonation of one UXO might detonate the second or other UXOs, the Applicant will discuss the situation with the MMO and agree the course of action to be taken.

29. There would also be no concurrent piling or UXO clearance between the proposed East Anglia TWO and East Anglia ONE North projects.

5 Draft Protocols for UXO Clearance and Piling

5.1 UXO Clearance

30. The final MMMP for UXO clearance will ensure there are embedded mitigation measures, as well as any additional mitigation, if required, to prevent the risk of any physical or permanent auditory injury to marine mammals. This will be developed in the pre-construction period, when there is more detailed information on the level of UXO clearance required and hence, it will incorporate the most

appropriate mitigation measures based upon best available information and proven methodologies at that time.

31. The Applicant is committed to using the best practicable means at the time to mitigate the impacts of the proposed East Anglia TWO project.

32. The protocol outlined below is in line with current best practice and will be updated no later than six months prior to UXO clearance activities being undertaken.

33. The effectiveness of these mitigation measures is described in **Appendix 1** - Effectiveness of Possible Mitigation Measures.

5.1.1 Mitigation

34. The final MMMP would involve the establishment of a suitable Mitigation Zone around the UXO location before any detonation. The Applicant will ensure that the mitigation measures are adequate to ensure no marine mammals are present within the Mitigation Zone prior to any UXO detonation, to reduce the risk of any physical or permanent auditory injury (PTS).

35. The methods for achieving the Mitigation Zone and reducing the potential impacts of any UXO detonation would be agreed with the MMO in consultation with Natural England and TWT and would be secured as commitments within the final MMMP. The required mitigation measures could include:

- All detonations taking place in daylight.
- The controlled explosions of the UXO, undertaken by specialist contractors, using the minimum amount of explosives required in order to achieve safe disposal of the device.
- Consideration of any commercially available alternative (e.g. Low Order techniques such as deflagration) or the use of bubble curtains, taking into account the environmental conditions within which they could be effective.
- Monitoring of 1km radius by marine mammal observers (MMOs) during daylight hours and when conditions allow suitable visibility, pre- and post-detonation.
- Deployment of passive acoustic monitoring (PAM) devices if the equipment can be safely deployed and retrieved.
- The activation of acoustic deterrent devices (ADDs).
- If required and where possible and safe to do so, a soft-start procedure using scare charges.
- The sequencing of detonations, if there are multiple UXO in close proximity to be disposed of near simultaneously, where practicable, will start with the smallest detonation and end with the larger detonations.

- Protocol in event marine mammals are observed in the Monitoring Area.

5.1.2 Concurrent UXO Detonations

36. The Applicant would ensure that no concurrent UXO detonations take place, i.e. there would be no simultaneous UXO detonations within the East Anglia TWO offshore development area (see ***section 4***).

5.1.3 Reporting

37. Reports detailing all UXO clearance activity and mitigation measures will be prepared. This will include, but not necessarily be limited to:

- A record of UXO clearance operations detailing date, location and times including information on the size of charges used.
- A record of mitigation measures such as ADD deployment, including the date, location, times, any operational issues, start and end times of watches by MMOs, start and end times of any acoustic monitoring using PAM, and details of all explosive activity during the relevant watches.
- A record of all occasions when UXO detonation occurred, including details of the activities used to ensure the Mitigation Zone is established and any occasions when activity was delayed or stopped due to presence of marine mammals.
- Any relevant details on the efficiency of the marine mammal exclusion methodology.
- A record of marine mammal observations, conditions, description of any marine mammal sightings and any actions taken.
- Details of any problems encountered including any instances of non-compliance with the agreed mitigation protocol.

38. A final report will be submitted to the MMO. The final report will include any data collected during UXO clearance operations, details of all mitigation measures, a detailed description of any technical problems encountered and what, if any, actions were taken. The report will also discuss the protocols followed and put forward any recommendations and lessons learned based on the mitigation measures used that could benefit future projects.

5.1.4 Communication and Responsibilities

39. The final MMMP will detail the communication protocol to ensure that all marine mammal mitigation measures are successfully undertaken for all UXO clearance operations.

40. The final MMMP will also detail all key personnel and their responsibilities to ensure that all marine mammal mitigation measures are successfully undertaken.

This will be developed based on the mitigation measures and personnel required (e.g. ADD operators, MMOs, PAM operators, Environmental Liaison Officer (ELO), UXO Manager) with the titles and responsibilities being refined depending on the contractual agreement.

5.2 Piling

41. The final MMMP for piling will ensure there are embedded mitigation measures, as well as any additional mitigation, if required, to prevent the risk of any physical or permanent auditory injury to marine mammals. This will be developed in the pre-construction period, when there is more detailed information on the proposed East Anglia TWO project design (and environmental conditions) and hence, it will incorporate the most appropriate mitigation measures based upon best available information and proven methodologies at that time.

42. The protocol will be developed in consultation with the MMO and relevant SNCBs, detailing the proposed mitigation measures to reduce the risk of physical or permanent auditory injury (PTS) to marine mammals during all piling operations. This will include details of the embedded mitigation, for the soft-start and ramp-up, as well as details of the Mitigation Zone and any additional mitigation measures required to minimise potential impacts of any physical or permanent auditory injury (PTS). Consideration will be given to the requirements following any breaks in piling as well as prior to piling commencing. The Applicant is committed to using the best practicable means at the time to mitigate the impacts of the proposed East Anglia TWO project.

43. The protocol outlined below is in line with current best practice and will be updated no later than six months prior to construction.

5.2.1 Mitigation

44. The final MMMP would involve the establishment of a Mitigation Zone around the pile location before each pile driving activity, based on the maximum predicted distance for permanent auditory injury (PTS).

45. The Applicant would ensure that the mitigation measures are adequate to minimise the risk of marine mammals being present within the Mitigation Zone prior to piling activity commencing, to reduce the risk of any physical or auditory injury.

46. The effectiveness of these mitigation measures is described in **Appendix 1** - Effectiveness of Possible Mitigation Measures.

5.2.2 Soft-Start and Ramp-Up

47. The Applicant would ensure that a soft-start and ramp-up procedure for piling is conducted for a minimum of 30 minutes. In the event that piling activity is stopped

for more than 10 minutes, the Applicant would ensure that the soft-start and ramp-up procedure is conducted prior to piling re-commencing.

48. Each piling event would commence with a minimum of 10 minutes at 10% of the maximum hammer energy, followed by a gradual ramp-up for at least 20 minutes up to 80% of the maximum hammer energy for all pile driving activities. This 30 minute soft start and ramp-up procedure is more precautionary than the current JNCC (2010b) guidance, which recommends that the soft-start and ramp-up duration should be a period of not less than 20 minutes.

49. During the 30 minutes for the soft-start and ramp-up it is estimated that marine mammals would move at least 2.7km from the piling location. This would therefore be greater than the maximum predicted distance of 1.2km for PTS from a single strike at the maximum hammer energy for monopiles of 4,000kJ, based on the unweighted SPL_{peak} NOAA (NMFS 2018) criteria:

- During the 10 minute soft-start it is estimated that marine mammals would move a minimum of 0.9km from the piling (based upon a precautionary marine mammal swimming speed of 1.5m/s); and
- During the 20 minute ramp-up it is estimated that marine mammals would move a minimum of 1.8km from the piling location (based upon a precautionary average marine mammal swimming speed of 1.5m/s).

5.2.3 Concurrent Piling

50. The Applicant would ensure that no concurrent piling events take place, i.e. there would be no simultaneous piling operations within the East Anglia TWO windfarm site during construction.

5.2.4 Other Mitigation Measures

51. The final MMMP for piling could also include additional mitigation such as:

- The activation of ADDs prior to the soft-start; and / or
- Monitoring of the 1km Monitored Area by MMOs during daylight hours and when conditions allow suitable visibility; and / or
- Deployment of a PAM device, if required, during hours of darkness and poor visibility.

52. The final MMMP for piling will detail all agreed mitigation measures, including provision for any breaks in piling and piling at night or in poor visibility, to ensure that the mitigation measures are successfully undertaken for all piling activity.

5.2.5 Reporting

53. Reports detailing the piling activity and mitigation measures would be prepared for all piling activity. This would include, but not necessarily be limited to:

- A record of piling operations detailing date, location, times (including soft-starts and ramp-up) and any technical or other issues for each pile.
- A record of mitigation measures such as ADD deployment, detailing date, location, times and any operational issues.
- A record of all occasions when piling occurred, including details of the activities used to ensure the Mitigation Zone is established and any occasions when piling activity was delayed or stopped due to presence of marine mammals.
- Any relevant details on the efficiency of the marine mammal exclusion methodology.
- A record of marine mammal observations, conditions, description of any marine mammal sightings and any actions taken.
- Details of any problems encountered during the piling process including instances of non-compliance with the agreed piling and / or mitigation protocol.

54. The reporting schedule is to be agreed with the MMO post-consent and may include weekly reports and a final report. Any final report would include information, such as data collected during piling operations, details of ADD deployment and / or other mitigation measures, a detailed description of any technical problems encountered and what, if any, actions were taken. The report would also discuss the protocols followed and put forward any recommendations and lessons learned based on the mitigation measures used that could benefit future construction projects.

5.2.6 Communication and Responsibilities

55. The final MMMP for piling will detail the communication protocol to ensure that all marine mammal mitigation measures, including any delays in commencing piling due to marine mammals being present in the area, are successfully undertaken for all piling activity.

56. The final MMMP for piling will also detail all key personnel and their responsibilities to ensure that all marine mammal mitigation measures are successfully undertaken for all piling activity. This will be developed based on the mitigation measures and personnel required (e.g. ADD operators, MMOs, PAM operators, ELO, Offshore Installation Manager) with the titles and responsibilities being refined depending on the contractual agreement.

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Appendix 1 - Effectiveness of Possible Mitigation Measures

1 The Effectiveness of Possible Mitigation Measures for UXO Clearance

1. Underwater noise modelling was undertaken for potential UXOs with a range of charge weights, as outlined in the ES (***Chapter 11 Marine Mammals***). This has been used to inform this current draft MMMP.

2. The underwater noise modelling for the ES (***Chapter 11 Marine Mammals***) used the thresholds and weightings based on the National Oceanic and Atmospheric Administration (NOAA) (National Marine and Fisheries Service (NMFS) 2018) criteria. It is important to note that the latest Southall et al. (2019) Marine Mammal Noise Exposure Criteria are the same as the NMFS (2018) criteria, however the names of the hearing groups have changed (Medium-Frequency (MF) Cetaceans are now classed as High-Frequency (HF) Cetaceans, and previous HF Cetaceans as Very High Frequency (VHF) Cetaceans).

3. Potential impact ranges have been included for both unweighted SPL_{peak} and weighted SEL. However, as outlined in the ES (***Chapter 11 Marine Mammals***), Peak Sound Pressure Levels (SPL_{peak}) are difficult to predict accurately (von Benda Beckmann et al. 2015) and tend to be significantly over-estimated by the modelling over increased distances from the source. Therefore, at larger ranges, greater confidence is expected with the calculations using the Sound Exposure Levels (SEL) metric rather than SPL_{peak}. However, the risk of PTS and therefore the mitigation has been based on the worst case for the maximum predicted impact ranges.

4. In addition, with increased distance from the source, impulsive noise, such as UXO detonation, becomes more of a non-impulsive noise. However, it is currently difficult to determine the distance at which an impulsive noise becomes more like a non-impulsive noise.

5. As outlined in the UXO modelling for East Anglia TWO (Subacoustech, 2019), *"an impulsive wave tends to be smoothed (i.e. the pulse becomes longer) over distance (Cudahy and Parvin, 2001), meaning the injurious potential of a wave at greater range can be even lower than just a reduction in the absolute noise level.*

An assessment in respect of SEL is considered preferential at long range as it takes into account the overall energy and the smoothing of the peak is less critical. The smoothing of the pulse at range means that technically it develops into a 'non-pulse' of the order of 2km to 5km. This range is still to be formally determined and will be different depending on the noise source and conditions." (Subacoustech, 2019).

6. Explosive noise is highly impulsive and an upper conservative estimate of 5km is suggested for the transition. It is therefore suggested that, for any injury ranges calculated using the impulsive criteria in excess of 5km, the non-pulse criteria should be considered more appropriate. As a result, 5km is likely to be the limit of risk of permanent auditory injury (PTS). However, the risk of PTS and therefore the mitigation has been based on the worst case for the maximum predicted impact ranges as set out below, rather than the 5km 'transition' range.

7. Based on the current predictive underwater noise modelling in the ES (***Chapter 11 Marine Mammals***), the maximum potential range for PTS for marine mammals from a UXO with a possible maximum charge weight of 700kg, based on the worst case scenario and modelling for impulsive sound over a large range (i.e. not accounting for change from impulsive to non-impulsive sound with increased distance) the maximum impact ranges could be:

   - Up to 11.1km for harbour porpoise using the NOAA (NMFS, 2018) unweighted SPL_{peak} impulsive criteria of 202 dB re 1 µPa; or
   - Up to 3.6km for harbour porpoise using the NOAA (NMFS, 2018) weighted impulsive PTS SEL criteria of 155 dB re 1 μPa^2s.
   - Up to 2.6km for grey and harbour seal using the NOAA (NMFS, 2018) unweighted SPL_{peak} impulsive criteria of 218 dB re 1 µPa; or
   - Up to 1.8km for grey and harbour seal using the NOAA (NMFS, 2018) weighted impulsive PTS SEL criteria of 185 dB re 1 μPa^2s.

8. Proposed mitigation could include, for example:

   - A pre-detonation search, where marine mammal observations of 1km radius prior to any ADD activation and any UXO detonation, including any scare charges, will ensure marine mammals are out with the immediate vicinity of the UXO location.
   - ADD activation for up to 55 minutes, this will ensure that marine mammals move away from the UXO location. Based on a precautionary marine mammal swimming speed of 1.5m/s (Otani et al. 2000) marine mammals would move at least 5.95km. Therefore, after the pre-detonation search of the 1km radius followed by 55 minute ADD activation, marine mammals would be at least 5.95km from the UXO location.

- Use of scare charges (or UXO soft-start procedure), if required, could commence ten minutes after the 35 minute ADD activation. The UXO soft-start procedure could involve a sequence of small to increasingly larger charge sizes which will be detonated in size order (with the smallest first) to allow additional time for marine mammals to leave the area prior to the main UXO detonation.
    - The size of charges and number required will be dependent on the size of the UXO to be detonated, but it is anticipated that for the maximum sized UXO of up to 700kg, this could involve up to six small charge detonations which commence at ten minute intervals, with a further interval of ten minutes before the detonation of the UXO. The total duration for the six small charge detonations would be 60 minutes. It should be noted that 700kg UXO devices is a worst case scenario and that for context, East Anglia ONE recorded 1x 700kg, 2x 499kg, 15x 200-300kg and 45x <200kg with an overall average charge weight of 137kg.

9. The proposed mitigation outlined above could give a total deterrence time for the ADDs (55 minutes) and soft-start sequences (60 minutes) of at least 115 minutes, and based on a swimming speed of 1.5 m/s, marine mammals should clear a radius of at least 10.35km. When added to the 1km radium for the pre-detonation search, any marine mammal would be a minimum distance of at least 11.35km from the UXO location.

10. Based on the 3.6km potential PTS SEL impact range for harbour porpoise, possible mitigation could include the use of MMOs and ADDs, without the need for any scare charges. For example, activation of the ADDs for 55 minutes prior to UXO detonation would allow marine mammals to move over 4.95km from the UXO location.

11. Based on the maximum 11.1km potential PTS SPL_{peak} impact range for harbour porpoise, mitigation could include the use of MMOs (1km Monitoring Area), ADDs for 55 minutes and scare charge sequence for up to 60 minutes, as outlined above, the overall mitigation procedure would allow any marine mammal to be a minimum distance of at least 11.35km from the UXO location

12. Therefore, after the proposed mitigation for the worst case scenario, there should be no harbour porpoise, grey seal or harbour seal in the potential impact range for PTS SEL from the largest UXO detonation.

13. The proposed mitigation would be revised if other mitigation methods are a suitable option, such as Low Order deflagration or the use of bubble curtains. However, the proposed mitigation outlined above is based on a worst case scenario that alternative mitigation options are not suitable.

2 Effectiveness of Mitigation Measures for Piling

14. Based on the current predictive underwater noise modelling as presented in ***Chapter 11 Marine Mammals*** of the ES (APP-059):

- The maximum potential range for instantaneous PTS (SPL_{peak}) from a single strike of the starting hammer energy of 400kJ would be 0.58km for harbour porpoise and less than 0.05km for grey and harbour seal.
- Mitigation, such as the activation of ADDs prior to the first strike of the soft-start, would allow marine mammals to move away prior to the soft-start and ramp-up. For example, the activation of ADDs for 10 minutes prior to the soft-start would allow harbour porpoise and other marine mammals to move at least 0.9km from the piling location (based on a precautionary average marine mammal swimming speed of 1.5m/s), which is beyond the maximum PTS predicted impact range of 0.58km for the starting hammer energy of up to 400kJ. Therefore, after the ADD activation there should be no harbour porpoise, grey seal or harbour seal in the potential impact range for PTS from the first strike of the soft-start.
- The estimated maximum ranges (without mitigation) within which cumulative sound exposure level (SEL_{cum}) for PTS could occur in harbour porpoise is estimated to be 6.4km and 21km for the maximum hammer energy of the monopile (4,000kJ) and pin-pile (2,400kJ), respectively. The estimated maximum ranges (without mitigation) within which PTS SEL_{cum} could occur in grey and harbour seal 4.9km for the maximum hammer energy of the monopile (4,000kJ) and 6.8km for the maximum hammer energy of the pin-pile (2,400kJ).

15. Mitigation for the East Anglia ONE windfarm consisted of a Monitoring Area of 500m around each individual piling location, each piling event commenced with a soft-start of at least 20 minutes and an ADD was activated for 15-30 minutes immediately prior to the soft-start to actively deter marine mammals from the area. During daylight hours MMOs conducted a dedicated pre-piling watch of the Monitoring Area for a minimum of 30 minutes prior to the commencement of soft-start piling. At night and during periods of poor visibility pre-piling monitoring was undertaken by a PAM Operator using a PAM system. The three dedicated dual role MMOs / PAM Operators undertook visual observations and acoustic monitoring for marine mammals during the installation of 102 three legged jacket foundations between the 25th April 2018 and the 30th January 2019. There were 675 hours and 38 minutes of visual observations and 880 hours and 46 minutes

of acoustic monitoring conducted throughout the survey. During this time there were only three marine animal sightings, two of which were while the vessel was in transit and the other was on site and resulted in a delay to soft-start operations. No acoustic detections were made. This indicates that the mitigation implemented during piling at the East Anglia ONE windfarm was effective and there was no risk of physical or auditory injury to marine mammals.

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