Natural England Offshore wind cabling: ten years experience and recommendations

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Summary

This note documents the experience Natural England has gained from advising on the environmental impacts of power cable installation over the last ten years, and to highlight where issues have arisen with both installation and maintenance that have caused concern for nature conservation. Annex 1 provides some detail of cases where impacts have occurred. In many cases the works resulted in habitat disturbance and loss/ change within MPAs that had not been assessed as part of the application, requiring additional work by the developer, regulator and advisors. Due to the experience we have gained relating to the actual impacts on the ground, we regularly find ourselves disagreeing with, or questioning developers' assessments of likely impacts of cabling works. This note provides evidence for our current advice to industry and regulators on offshore wind cabling activities and explains where our current concerns with regards to impacts from cable installation have stemmed from. It seeks to emphasise that better solutions can and should be found for both the environment and for the offshore wind industry, which should also result in time savings for all parties post consent.

In particular it makes recommendations for the industry to: avoid cabling in sensitive/protected habitats; to change the way impact assessments are carried out so that they are more rigorous in the data collected and the emphasis placed on the likely range and scale of likely impacts through the lifetime of a cable; to be more realistic about the evidence gaps and the limitations in installation technology avoiding over-optimistic engineering predictions that are unable to be delivered on the ground; to invest in greater levels of detail in information collection and project design at earlier stages of the project; to consider mitigation at much earlier stages of a project planning and for monitoring to improve the evidence base on cable installation impacts and the recovery from these.

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1. Introduction

The offshore wind industry has grown in the UK over the last 15 years from initial installations of 30 turbines at Scroby Sands and Kentish Flats to the more recently consented projects at Dogger Bank of up to 400 turbines. Related to this there has been a step change in the amount of cabling activity to much higher numbers and lengths of inter-array and export cables needed to service these projects. This has necessarily led to interactions of cables with a wider range of substrates and associated habitats and species, and the need for differing installation techniques, successful or not.

At the same time as this period of offshore wind development there has been a large increase in the number of Marine Protected Areas (MPAs) designated (from around 16% of inshore English waters designated in 2009 to 38% by 2016) leading to much greater interactions between cabling activities and designated sites.

The limitations in availability of grid connection on land has led to cables from more than one project coming into the same or nearby areas leading to increased pressure on the habitats and species in those locations.

2. Offshore wind cable history and evolution

In the early offshore windfarms with small numbers of turbines located close to shore there were multiple export cables transmitting at 33kV. With the development of larger windfarms further from shore the use of offshore substations to step up voltage has become standard and transmission is now at 130 -150kV HVAC. The table below gives figures for the cables from some sample developments to illustrate the change in scale of cabling associated with offshore windfarm development.

Windfarm	Year of operation	Number of turbines	Number of export cables	Export cable length per cable (km)	Inter array cable length (km)	Area of seabed impacted m^2
Scroby Sands	2004	30	3	4.2	20	
Kentish Flats	2005	30	4	9.4	21	136,000 export 80,000 inter-array
Greater Gabbard	2012	140	3	45	175	
Hornsea 1	2019	332	3	142	450	6,000,000 export 4,500,000 Inter-array

Projects currently in pre planning (e.g. Hornsea 3) are proposing to use 6 export cables per project. Thus it can be seen that there has been a significant increase in the length of cable installed in the marine environment in relation to offshore wind in the last 10 years with many more to come as those Round 3 projects consented and in planning move into construction.

HVDC cable technology becomes more viable with increased distance from installation to shore. It has yet to be used for offshore wind in the UK due to costs (although there are applications being submitted using this technology) but could result in overall benefits to the environment. Although its use would potentially require more offshore infrastructure due to the need for collector and conversion stations and larger onshore converter substations, depending on the project design there is potential for fewer cables to be required offshore in a HVDC system which would be of benefit in reducing interaction with the marine environment and thus potentially negative impacts.

3. Impacts from cable installation and related concerns for nature conservation

It is usual for an Environmental Statement to assess at a high level the impact of cable installation by a possible four methods: ploughing, jetting, trenching/ cutting and vertical injector with either simultaneous lay and burial of the cable or laying of the cable by a surface vessel and then subsequent burial using another device. Cable installation tools are either towed by a surface vessel or self-propelled. Prior to cable laying, grapnel runs are carried out and boulder and UXO clearance may be necessary to clear the route for the installation tool/ vessel. More recent applications have assessed sandwave clearance, which may be required to reduce the slope/ flatten the seabed to achieve more optimum burial and enable installation tools to operate. Cable protection in the form of concrete mattresses, rock placement, grout or sand bags or frond mattresses is essential at cable crossings and may be required in other areas where optimum burial depth cannot be achieved (even after repeated attempts to bury the cable). All this information is used to calculate the area of seabed that may be impacted by the worst case scenario installation method (usually that with the biggest footprint). A description of the typical cable installation process can be found in the Offshore Wind Programme Board Overview of the offshore transmission cable installation process in the UK.

Cables associated with the early Round 1 windfarms were typically installed by plough in soft sediment environments (mud and sands). Advice from Natural England was that cabling was a one off activity leading to temporary disturbance of the sediment and habitat and that due to the nature of these habitats, which are generally tolerant to disturbance, there would be recovery of the sediment and associated fauna within relatively short timescales (less than a year). However, experience gained over the last 10 years has shown that cable installation is often not a one off activity, (with maintenance and repair works, cable reburial, additional cable protection or even replacement of cables/cable sections now frequently needed), and additionally that the installation techniques proposed in Environmental Statements are often found not to be feasible once ground conditions are better understood and contractors are on-board. With the increase in scale of cable installation, many different habitats are being impacted that have less potential for recovery/slower recovery rates than those more robust sediments of the earlier installations. This has led to greater impacts on marine and coastal habitats and species than those assessed at the time of consenting, effectively rendering the assessments in the Environmental Statement inadequate.

Dealing with these issues post consent when a project is going into construction has led to difficulties and frustration on the part of advisors, regulators and developers. At this stage supply chains are often in place leading to relatively few options to change or minimise environmental impacts due to cables, contractors and vessels already being procured. Additionally, developers are under pressure to meet contractual timescales for installation leading to changes to proposals occurring in tight time frames, which passes the pressure on to regulators and their advisors. There may be a requirement for new Habitats Regulations Assessments or MCZ assessments to be undertaken at short notice[1]. Where works may now lead to a significant impact, potential adverse effect or hindering of the conservation objectives[2] of an MPA it can be challenging to find solutions that enable cables to be installed within the time constraints while avoiding the detrimental impacts. This has led to great impacts than were considered at the consenting stage, and a risk of failing to protect designated MPA features. Better outcomes could be gained for the project and environment through more realistic consideration of the issues at the consenting stage. We recognise that at the consenting stage it is outlined to the developer that any deviations from that which is consented is at the developer's risk, but in reality the risk is shared across all interested parties including government.

4. Pressures and impacts from cable installation

Information on feature specific pressures exerted by cable installation can be found in the advice on operations for the relevant MPA. An example for Margate and Long Sands SAC can be found here:

The key pressures of concern in relation to cable installation are:

- Abrasion/disturbance of the substrate on the surface of the seabed
- Changes in suspended solids (water clarity)
- Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion
- Smothering and siltation rate changes (Light)
- Physical loss (to land or freshwater habitat)
- Physical change (to another sediment types)

In harder substrate environments there may be loss of habitat due to the cable installation. Additionally where sandwave clearance or cable protection are proposed or used there are additional pressures relating to dredging of large volumes of material or loss of/ modification to habitat under hard rock placement. In an MPA designated for a species e.g. birds there are additional considerations relating to the disturbance caused to the species as well as any habitat they may rely on. Other pressures are associated with the infrastructure used for

[1] An appropriate assessment may be required under regulation 63 of The Conservation of Habitats and Species Regulations 2017, or an MCZ assessment under the Marine and Coastal Access Act if the activity is likely to have anything other than an insignificant impact on an MPA and these impacts have not previously been assessed or sufficiently assessed as part of the consenting process.
[2] If an activity is deemed to have an adverse effect on an SAC or SPA or hinder the conservation objectives of an MCZ then that activity cannot be permitted unless it can be shown that there are no alternatives, that it has imperative reasons of overriding public interest and that suitable compensation or measures of equivalent environmental benefit for the damage can be implemented. To avoid these levels of impact operations must be carried out in a manner, with suitable reduction, avoidance and mitigation of impacts so as not to cause an adverse impact on an SAC or SPA or hindering of the conservation objectives of an MCZ.

cable installation such as anchor placement of vessels, beaching of vessels nearshore and requirements for boulder and UXO clearance along cable routes.

The impact of these pressures on an MPA, and Natural England's level of concern regarding them, then relates to:

- the magnitude of the pressure (e.g. number of cables to be installed and footprint of the installation method)
- the duration of the pressure (how long cable installation will realistically take as well whether the impacts from the operation are temporary)
- timing of the installation in relation to sensitive periods
- and the sensitivity and recoverability of the habitat or species in question.

For example ploughing a cable into highly mobile sands and chalk bedrock may have the same footprint, but the two habitats will recover very differently. The highly mobile sand habitat will be less sensitive and recover more quickly than the chalk bedrock which may take much longer to recolonise due to the species present and does not have the ability to recover morphologically.

5. Experience gained from cable installation to date

As discussed above, there are several reasons why cabling activities and our advice relating to them has evolved over the last ten years. This is largely due to the experience that has been gained post consent when projects move into construction. At this point it has regularly been found that different or previously unknown impacts arise that have not been assessed, or sufficiently assessed, as part of the consenting process. This results from over confidence of the applicant in their ability to install cables, over optimistic expectations of engineering solutions to complex problems or a lack of understanding of the complex marine substrate and ground conditions. In many cases changes to cable installation techniques, remedial works and additional cable protection have resulted in habitat disturbance and loss/ modification within MPAs that had not been assessed as part of the application, requiring additional work by the developer, regulator and advisors. It is therefore imperative that assessments are improved at the consenting stage in order that regulators and advisors are confident that a deliverable installation method has been proposed and a realistic level of impacts has been assessed in order to avoid these issues arising later. As highlighted in the Offshore Wind Programme Board paper (Overview of the offshore transmission cable installation process in the UK), earlier involvement of the right expertise for cable installation and burial planning would help to alleviate some of these issues by ensuring that more accurate methods statements are submitted, leading to consents that have considered the full potential range of situations that may be encountered for that project. This should be complemented by detailed survey data to inform decisions related to ground conditions ("past experience of installation issues resulting from unexpected seabed conditions serves to underline the importance of effective and early survey planning"). Feedback from insights gained on previous projects is also a fundamental requirement currently receiving insufficient attention by the sector.

The following list highlights some of the key issues that have arisen, which are explained in more detail in Annex 1 with examples. Although we understand that some of these issues may have been unavoidable, with current knowledge they should be assessed and mitigated for if needed at application stage.

- Changes to assessed cable installation methods due to more information becoming available post consent/ techniques not working in the field
- Predicted range of impacts/quantities, even after post consent revision, still not fit for purpose when compared to actual installation impacts
- Cable installation in a wider range of substrate types/ habitats
- Insufficient cable burial depth achieved in practise
- Cables becoming exposed and free spanning cables
- Secondary scour around cable protection and at cable crossings
- Need for additional cable protection due to above 3 reasons
- Installation/ repair timetable falling behind/ over running requiring work in sensitive periods for certain species
- Additional need for jointing pits/ flotation pits
- UXO/ boulder clearance with the actual number of UXO targets often far exceeding that assessed
- Pre-sweeping/ sandwave clearance
- Need for cable repair/ replacement
- Annex 1/Saltmarsh impacts – subject of another paper

6. Content of an assessment of cable impacts

The following points are made in the National Policy Statement for Renewable Energy Infrastructure EN-3 (section 2.6.113) and must be considered along with the additional detail below:

'Where necessary, assessment of the effects on the subtidal environment should include:

- *loss of habitat due to foundation type including associated seabed preparation, predicted scour, scour protection and altered sedimentary processes;*
- *environmental appraisal of inter-array and cable routes and installation methods;*
- *habitat disturbance from construction vessels' extendible legs and anchors;*
- *increased suspended sediment loads during construction; and*
- *predicted rates at which the subtidal zone might recover from temporary effects.'*

Natural England advise that a full assessment in an application should include:

- Detailed information on ground conditions and clear evidence of the likelihood of success of proposed burial techniques in those conditions. Currently these are usually provided in a cable installation plan post construction which can be too late in the process where sensitive habitats and species are likely to be impacted. There needs to be a *very* realistic worst case scenario (WCS) based on engineering knowledge and experience and an alternative installation plan/technique should the ground conditions be unsuitable for the preferred method. Although this might mean a wider cable installation envelope and a '*worse'* WCS, there is a need to be more precautionary as a result of negative experience with a number of existing projects. Should the developer wish to have a more defined WCS – ground investigations and associated data need to be presented at the application stage rather than post-consent. (This also relates to the next point below).

- Changes to assessed cable installation methods due to more information becoming available post consent/ techniques not working in the field. The Offshore Wind programme board paper states ‘*Contingency measures should also include plans for approvals of necessary changes to the installation methodology as, in the past, projects have needed to make late changes in response to unforeseen seabed conditions or weather changes while the vessel is on-site*.’

- Impacts related to bringing vessels inshore (associated beaching or floatation pits)

- An assessment of likely post-construction issues including the potential for cable exposures, scour, secondary scour and an assessment of the expected WCS for associated remedial work as a contingency to future proof applications. This should include any needed change to installation techniques for this work as detailed above.

- Assessment of impacts of realistic number of cable repairs or replacements using information gained from previous developments

- Realistic predictions of the amount of cable protection (including height, width, length) and the type of cable protectionto be used along with an assessment of the impact on habitats and species at the required locations. Consideration should be given as to whether this leads to habitat loss and whether it will be conditioned to be removed on decommissioning. The assessment should include the proposed locations of cable protection rather than a generic amount along the route with specific assessment of the impacts of areas on habitats within MPAs. An assessment of potential impacts to physical processes should also be undertaken to look at potential impacts to sediment transport which may impact habitat extent and quality.

- A realistic assessment of the number and impact of cable grapnel runs, UXO, boulder and sandwave clearance where relevant with a clear indication of the temporal nature of these impacts.

- Realistic worst case scenario predictions of area of each relevant habitat type/ species impacted along with realistic assessment of recovery. Evidence from developments of similar scale and in a similar habitat should be analysed and presented. The assessment should also refer to sensitivity and recoverability information that is provided in the most up to date Conservation Advice for each feature.

- An assessment of how the above predictions relate to the conservation objectives of any relevant MPA

- Proposals for monitoring and remediation/ alternatives, particularly where installation techniques and their impacts on designated features are unclear. Where monitoring is required to inform remediation the methodology should be agreed with relevant bodies to ensure the future surveys are fit for purpose.

7. Mitigation[3]

Cabling can have low environmental impacts if the operation is carefully planned and appropriate mitigation is put in place. The standard approach of 'avoid, reduce, mitigate' should apply where firstly impacts, particularly on a sensitive feature, should be avoided. If this is not possible then impacts should be reduced by selection of appropriate methods and finally any remaining impacts should be mitigated for. Mitigation for benthic impacts in the National Policy Statement for Renewable Energy Infrastructure EN-3 (section 2.6.119) includes the following points:

'Construction and decommissioning methods should be designed appropriately to minimise effects on subtidal habitats, taking into account other constraints. Mitigation measures which the IPC should expect the applicants to have considered may include:

- *surveying and micrositing of the export cable route to avoid adverse effects on sensitive habitat and biogenic reefs;*
- *burying cables at a sufficient depth, taking into account other constraints, to allow the seabed to recover to its natural state;'*

There are a variety of ways to minimise or mitigate impacts of cable installation and routing including:

- Micro-siting/routing, modification to the route to minimise interaction with sensitive features is important and commonly done either directly by developers or after consultation with Natural England. For micro routing to be successful post-consent it is necessary to ensure there is sufficient cable to do so, which can be an issue in relation in terms of timing of surveys to inform procurement and also taking into account technical logistics of bending a cable.
  Examples of where route selection has worked successfully are at two windfarms which needed to address the impacts of bringing cables ashore through areas supporting reef habitat in and outside of MPAs. At the first windfarm, during the pre-examination phase there were a number of cable options which were reduced down to the preferred option. Part of this options review process was to undertake habitat surveys of the cable routes followed by a review of the habitat sensitivity to assist with route selection. One of the main reasons for not choosing one option was the presence of stony reef. The other project had a large cable corridor consented and the habitats were surveyed within the full cable corridor to identify presence of reef habitats with the intention of micrositing/positioning the cable around reef. In the end, whilst the only reef found was not located along the preferred cable route and therefore impacts were avoided.

- Carefully selecting techniques for burial to reduce sediment plumes or avoid features can be very helpful. Horizontal directional drilling (HDD) can be used in some circumstances to fully avoid sensitive areas. For HDD to be considered as viable, pre-consent geotechnical investigations are required to confirm what is achievable. Undertaking these investigations will require a Marine licence and/or planning

[3] Adapted from Natural England Submarine Cables Handbook – internal document

consent.

- Avoiding sensitive times of the year can completely avoid a potential impact. For example, avoiding nesting and overwintering periods for birds, or times of the year when the feature is present.

- When cable protection is needed, materials can be selected to match the environment (when on mixed sediment or cobbles, rock of similar diameter and material as the receiving environment should be used as an alternative to the current blanket approach of sourcing granite from Norway).

- Where cable protection is needed it is also important to pay attention to the sand wave field in the area surrounding the rock amouring/placement location. The rippling in the sand in the wider area can show how mobile the area is and the sediment transport direction. Where possible, cable protection in a dynamic environment should not be placed perpendicular to the sediment transport (i.e. the long side of the rock protection should not run at angles close to parallel with the ripple crests) as this can result in large scour pits. If this is considered necessary then the associated issues highlighted above should be considered and addressed as part of the application. Similarly the placement of cable protection at 90 degrees to near shore sediment transport pathways is to be avoided as it can affect downstream sediment transport. The report undertaken for one windfarm projects showed that cable protection within the 10m depth contour could cause disruption to longshore sediment transport such that it may cause a breach at Spurn Point.

- Sandwave clearance is undertaken to avoid exposure of the cables in the future, but there is currently insufficient evidence as to the impacts and effectiveness. Its use therefore needs to be carefully considered, and where possible avoided in an MPA as in many cases the volumes dredged can be very large. As with any activity the ‘avoid, reduce, mitigate’ hierarchy should apply. Early discussion with Natural England is recommended as our advice will depend on the location. Depositing of any dredged material should be at a location that enables it to remain within the sediment system. We advise that any sediment extracted should be deposited up stream of cable trenches to encourage natural backfill.

8. Recommendations

Natural England therefore consider that cable installation, repair and maintenance have the potential to impact the natural environment in a significant way and have the following recommendations:

i) Cables should be routed away from sensitive habitats wherever possible e.g. those in which damage due to installation would be permanent, recovery slow or the habitats and species are rare or of high environmental value such as *Sabellaria spinulosa* reef, saltmarsh and chalk reef.

ii) The number of cables per project should be minimised through project design.

iii) Cabling in dynamic mobile sediment environments should be carefully considered (in project design) to avoid cable exposures occurring and subsequent additional cable protection being required.

iv) Cabling should not be assessed as a one off activity and a full assessment should take place at consenting stage of the cumulative impacts of cable installation and maintenance including the impacts of related cable protection and remedial/ repair works once operational.

v) Every effort should be made to use (or gain where there is a concern) pre-application geotechnical information to inform a realistic assessment of cable burial tools and options and their impacts as part of the consenting process. This should avoid the need for changes to the methods assessed in the Environmental Statement when a project moves into construction.

vi) Where there is any doubt as to the feasibility of installation this should be clearly communicated, particularly where there is interaction with an MPA. In this situation it may be useful to consider a wider range of techniques or other possibilities in order to ensure the worst case scenario is fully covered and impacts on the MPA can be assessed. Based on previous experience Natural England will take a precautionary approach in its advice on consenting in sensitive habitats where there is uncertainty around the impacts.

vii) Taking account of worst case scenarios and gathering the necessary level of information at the point of application may be at considerable cost to the developer but can be offset by the reduced risk post consent of having to develop bespoke techniques/kit at very short notice. Additionally there is a large time cost (with associated financial implications) post consent to all parties through consultation on changes which could be saved.

viii) Conditions and discussions relating to cable installation and maintenance, with the detail behind them, should be clearly documented through the consenting process in order that the understanding and background is retained into construction of a project through any personnel changes in all parties.

ix) Where it is not possible to avoid an MPA and impacts are likely to be significant, early consideration of IROPI and compensation or measures of equivalent environmental benefit may well be the best option for the environment and project.

x) If we consider that insufficient information has been provided or inadequate assessment of the potential range of impacts, Natural England may advise that the application is inadequate and not fit for submission

xi) Monitoring of the impacts of and recovery from cable installation and repair has not been sufficient in many sediments/ habitats to provide an evidence base to advise on the impacts to sensitive habitats with confidence. Therefore until this evidence base is improved monitoring of export and inter-array cable installation impacts and recover should be implemented as a marine license condition.

9. Annex 1: Examples of impacts from cable installation and operations and maintenance

A1 Insufficient cable burial depth achieved in practice

At a number of windfarms it has not been possible to achieve the burial depth proposed in the Environmental Statement due to a combination of local ground conditions and inability of the tools to operate effectively in those conditions. In some cases this does not cause problems i.e. reburial attempts are successful or, as in other cases, the cables are left without further remedial work to bury the cables. However, in many areas this has led to repeated attempts to bury cables using the same or different tools, or the need for remedial cable protection due to risks to the cables and other sea users. In an MPA or a sensitive area the consequences of this can be repeated abrasion and disturbance to a habitat for which only one off disturbance was assessed and similarly further increases in suspended sediment. Where the habitats and species are sensitive to these pressures then prolonged disturbance increases the magnitude of the effects beyond that assessed at consenting. Impacts of additional cable protection are covered in Annex 2.

Examples:
At one site it was proposed to use stone bags in areas of insufficient burial to provide further protection to cables and a marine license was subsequently granted for this although ultimately the stone bags were not used.
At another offshore windfarm it was initially attempted to bury the inter-array cables using a plough which was not sufficiently successful. Following this a jetting tool was used, although this was also not sufficiently successful after a number of passes. Ultimately rock placement was required to ensure the integrity of the cables.
Elsewhere a mass flow excavator (extreme jetting tool) was used with some success to rebury cables. This posed more of a challenge in mixed sediments (presenting a harder substratum) than in softer sediments. Additional cable protection within an MPA that was not assessed at the time of application has subsequently been requested at this site.
At another site optimum burial depth was forgone in recognition that by cutting into the chalk bedrock to install the cable the bedrock provided appropriate protection to both cable and other sea users.
Two interconnector cables have applied for additional cable protection in MPAs that was not assessed at the time of application due to insufficient data being collected and used to predict burial depths and therefore ground conditions in reality differing to those that were assumed.

A2 Cables becoming exposed

Cables can become exposed either due to initial insufficient burial as detailed above or due to burial in mobile sediments which then migrate leaving the cables exposed. Impacts are similar to above where either reburial or additional cable protection is required. In the last couple of years sandwave clearance has been proposed and used in mobile sediment environments. This is covered in a separate section below.

Examples:
Since installation at x windfarm the majority of the export and inter array cable located within

the sandbank system have been exposed and free spanning and in other areas buried to depths >9m.This is due to the migration of the sand bank system south eastwards into the North Sea. However, nothing has been done to address the exposed cables.
At several windfarms cable exposures occurred requiring rock armouring in places. At one development surveys showed 16 exposures on export cable route and 29 on inter-array cables which required some remedial cable protection. At another a number of short exposures were observed. Additional jetting was required to remediate this with rock placement on exposed sections of the export cable. At a third site 77m export cable became exposed this was not considered a large impact and no remediation was required.

<u>A3 Scour and secondary scour around cable protection and at cable crossings</u>
Scour and secondary scour are of concern due to the potential to cause further destabilisation of the sediments and thus the further requirement for more remedial work. By their nature they will lead to additional abrasion, disturbance and impact on form and function of a habitat that has not been assessed as part of an application.

Examples:
At the crossing of a windfarm export cable and an interconnector cable, the cables became exposed due to their installation close to the edge of a dynamic sandbank. Remedial works were undertaken using locally sourced sand and gravel but were unsuccessful in keeping the cables buried. Further works were undertaken using rock armouring which then required an additional phase of works due to scour around the edge of the rock amouring. All of these works resulted in habitat disturbance and loss/ modification within MPAs that had not been assessed as part of the application, requiring additional work by the developer, regulator and advisors.
In a different location significant scouring of the seabed has occurred as a result of rock armouring placed over the export cable, with scour pits occurring which are deeper and cover a wider area than originally predicted (one pit is over 5m deep and 200m in length). Large areas of free spanning cable are also exposed. A cable scour remediation project has been implemented since the 2015 surveys were undertaken, resulting in rock placement around many of the shallow buried and exposed cable areas
Monitoring has shown that the level of impact from scour protection is influenced by its orientation in relation to local sediment transport patterns. In this instance the rock berm was placed perpendicular to the local sediment transport field (parallel to existing ripples) leading to the creation of scour pits several orders of magnitude larger than the rock berm. This in turn leads to greater than predicted impacts in terms of further habitat loss and disturbance. These impacts could be minimised whilst still protecting the cable by orientating the scour protection differently in line with local sediment transport patterns. As described in a previous section where this is not possible due to the cable orientation then the secondary impacts should be considered, assessed and addressed where necessary.

<u>A4 Need for additional cable protection due to above 3 issues</u>

Impacts of additional cable protection are covered in Annex 2.

<u>A5 Changes to cable installation technique</u>

This occurs where either new geotechnical information becomes available post consent and it is discovered that the techniques assessed at the time of consenting are now not sufficient to bury the cable, or new technology has come along since consenting that is more appropriate to the cable and the environment in which it is being installed. Where the impacts from the change to technique are within the parameters of those assessed at the time of consenting the change may not be problematic (although still requires time on the part of developers, regulators and advisors). Issues can arise where the change in technique impacts on an MPA, further assessment and potentially mitigation is required depending on the level of effects. As highlighted earlier the Offshore Wind programme board paper states '*Contingency measures should also include plans for approvals of necessary changes to the installation methodology as, in the past, projects have needed to make late changes in response to unforeseen seabed conditions or weather changes while the vessel is on-site*.'

Examples:
As described previously, at one site the installation technique was changed to using a mass flow excavator for the second cable installation which has wider and deeper impacts than those assessed under jetting in the ES. There was also remedial burial for the first cable using a mass flow excavator where the original techniques did not achieve optimum burial depth. The mass flow excavator had a 15m impact width, three times greater than the cable corridor width assessed in the ES. Use of the tool also raised concerns about increased suspended sediment concentrations, loss of fines when backfilling the material, impacts of stockpiling material and backfilling techniques and subsequent recovery of the habitat. Lack of evidence on the impacts of the technique meant that a greater level of monitoring of recovery was required, some of this showed persistent grooves in the seabed where stockpiled material was dredged up and non uniform recovery.
At another site the installation technique was changed from a plough to a cutter to enable cable installation in the chalk.
To install the export cable at another windfarm a mass flow excavator was used which was different in impacts to the original project installation and assessment.

<u>A6 Installation/ repair timetable falling behind/ over running requiring work in sensitive periods for certain species</u>

To mitigate for impacts on species in sensitive periods, such as feeding or roosting birds or migrating and spawning fish, timing restrictions may be included as a marine license condition. Where changes occur to the application prior to commencing construction, installation works over run or run into sensitive periods then disturbance is caused to these species that was not assessed as part of the original application, or was assessed and thought not to require mitigation measures. This leads to difficult decisions for advisors and regulators, and potentially long construction delays for developers, where works need to be completed whilst avoiding detrimental impacts on the species.

Examples:
At a windfarm the developer needed to reinstall their cable in the inter-tidal during the seasonal restriction for over-wintering birds in an SPA. A new appropriate assessment was required as this had not been previously assessed and there were large numbers of birds using the areas. Consequently a package of mitigation measures was agreed to enable the repairs to go ahead. This included minimising vehicle movements, marking a limited working corridors, no night working /lighting, cold weather restrictions and no coastal working practices 2 hours either side high tide. In addition to the mitigation measures the developer

aimed to reduce overall disturbance in the site by reducing recreational disturbance in the area, including making educational signs and leaflets and funding an extension of the local natural ambassadors programme where people were present on the foreshore to educate people on the impacts of bird disturbance.
At another windfarm the cable installation took longer than predicted, over running the end of the consented working window. Emergency real time judgments and assessments had to be made, in relation to whether or not the installation work in the intertidal could be completed or halted with the cable tied off until the following consent window. It was determined at that time that both options would be significant, and this put everyone under considerable pressure. In the end, the fair weather conditions meant that completion of the installation was the least worse option.
Similar issues were encountered at two more windfarms where construction windows over ran or additional work was needed requiring works to impinge on restricted periods.

A7 Pre-sweeping/ sandwave clearance

As discussed above, in areas where there are sandwaves and megaripples it may be difficult to achieve optimum burial depth and slopes may be too steep for cable installation machines to operate on (>15 degrees). The technique involves dredging the tops of the sandwaves (usually using a trailer hopper suction dredger or mass flow excavator) in order to install cables in a flatter area where machines can operate and cables are less likely to become exposed. Local levelling of smaller features by dragging a plough across the area has also been proposed. Dredged material is disposed of in a licensed area. To put it in context the figures proposed for dredging at a windfarm site are similar to those extracted from a medium sized aggregate extraction area in a year, therefore the proposed operations are not insignificant volumes (one windfarm applied for 541 600m^3 for dredging over inter-array and export cables – an aggregate extraction license can be from around 83 000m^3/year to 1 000 000m^3/year). However the difference in impacts between aggregate extraction and sandwave clearance are that aggregate is extracted in a discrete area and removed from the system, whilst sandwave clearance may be over a larger area if it includes an export cable route and the material can be retained within the system depending on how and where it is disposed of.

As these works have only been proposed and carried out relatively recently there is currently no evidence on how well this technique works, whether cables remain buried thus avoiding the need for additional cable protection, and how quickly dredged areas recover. A number of projects have applied to undertake sandwave clearance post consent, however forthcoming projects should fully assess the impacts of any likely sandwave clearance at the time of application in order for the application to be complete. Full consideration needs to be given to the volumes to be dredged, areas for disposal of dredged material and impacts on the benthos and sediment transport. Natural England advise that, until further evidence is available on its efficacy as a technique and the timescales for recovery, sandwave clearance should be avoided within MPAs due to the potential impacts. Additionally, in any sandwave clearance assessment we advise that it is best practise to deposit the material upstream of the extraction site to enable natural processes to work the material into the area as quickly as possible and reduce impacts.

A8 Floatation pits

Floatation pits have been required at one offshore windfarm to enable the cable installation barge to get close to shore. It is usual for a vessel to be brought in close to shore and often to beach on nearshore or intertidal soft sediments. In this instance it was not possible to find a vessel that could beach on the harder substrate close to shore. Therefore, to enable the installation vessel to operate in the shallow water near to the cable landfall an application was made to dig 6 floatation pits (each 160m x 45m and 3m deep) with an excavator, which allowed the installation vessel to remain floating at low tide and avoid being beached/grounded on the harder seabed surface. Once cable installation works are completed the pits will be infilled with the material that was excavated, however as excavation was in chalk bedrock the habitat is unable to recover geologically, although it may recolonise in a similar manner to what existed previously. Ongoing monitoring should inform the extent of the impact and recovery and thus any similar future situations. These activities were not assessed as part of the original application. This case occurred outside an MPA – within an MPA it may well have been difficult to avoid an adverse effect or hindering of the conservation objectives of the site. The consequences of this level of impact on a designated site are that the features are damaged and thus less resilient to further impacts. This may in turn lead to impacts from future activities being assessed with increased caution and considered unacceptable or less acceptable as well as impacting on the condition of the feature or site (e.g. the feature may become in unfavourable condition).

A9 Jointing pits /HDD exit pits

Horizontal directional drilling (HDD) is often chosen as the cable installation method at landfall. Although normally more expensive than other methods it can be a useful tool to avoid sensitive intertidal areas or minimise disturbance during construction. HDD cable installation usually starts on land and follows seawards, where the installation tool has an exit pit at the seabed in shallow water. In order to bring the tools back to the surface and to join the cable to its offshore portion an area of seabed needs to be cleared and levelled so excavation works may be required. In one recent windfarm consultation, the size of one such exit pit was estimated at 1500 m^2 with the depth of excavation of up to 4 m. Taking into account that there may be multiple cables installed for a project, the total area subject to habitat loss and disturbance may be quite large. The impact longevity will depend on the nature of the seabed material and sediment transport processes in the area. The significance of impact will depend on the conservation status of the area and sensitivity of the habitats. Similar impacts could be expected from jointing pits where sections of a cable or multiple cables are connected. The impacts from clearing and excavating large areas for the purposes of cable jointing works need to be carefully assessed alongside other cable installation impacts at the time of application.

Example:
At one windfarm, following detailed design of the joint pit requirements the developer identified the need to increase the maximum dimensions of the joint pit for the second cable from approximately 250m in length to up to 600m. This was necessary in order to provide a sufficient grade in / grade out area at the point that the cable enters and exits from the pit, taking account of operational constraints such as water depth and the technical limitations of the cable burial process. With a width of 25m, the estimated seabed footprint of the joint pit excavation increased from 8,899m^2 to 18,750m^2, including a 25% contingency.
Overall NE were content that given the location and temporary nature of the effects of using Mass Flow Excavation (MFE) for the joint, that the proposed variation request would not

have a significantly greater impact on the Annex I features of the SAC, from those previously considered in the Appropriate Assessment; even with the increased footprint. We noted concerns with the use of MFE leaving grooves that do not uniformly recover and required further info on number of passes etc.

A10 UXO Clearance

UXO investigation and clearance may be required within the cable corridor to ensure safety during construction operations. As the detailed information regarding number of targets and size is only collected prior to construction, it can be difficult for a full assessment to be undertaken during consenting. This can be problematic as UXO clearance is a noisy activity and assessments need to be undertaken of impacts on marine mammals both alone and in-combination with other activities such as piling. In some cases the actual number of UXO found post-consent is far greater than the predicted number originally assessed.

Example:
At one windfarm, the predictions and assessment had to be revisited several times with much higher numbers of targets involving further Appropriate Assessments, delays and frustration to all parties.

A 11 Boulder Clearance

This takes place where there is a need to remove boulders (typically greater than 300mm in any direction) from the cable installation route in order to enable safe and effective passing of the installation tools and thus achieve sufficient burial of the cables. Boulder clearance can lead to additional disturbance to sensitive habitats and therefore should be fully assessed as part of the application to enable all the impacts to be considered. Natural England's preference is that where necessary boulders should be moved to the side, rather than relocated to a new area, in order to keep the seabed habitat as similar as possible to unimpacted conditions. There are two main methods of boulder clearance – using a grab or plough – of these the use of a grab has much less of an impact on the seabed and should be used as the method of choice, particularly in sensitive habitats. Use of the plough can create a 25cm berm on either side of the plough. Where there are sensitive habitats, or indeed the boulders are part of a feature of an MPA, further consideration needs to be carefully given to the impacts of boulder relocation. As with a number of the other activities associated with cable installation, a lack of full information to allow a realistic assessment during consenting can lead to greater difficulties finding workable solutions later on.

A12 Monitoring and recovery

Where monitoring data is available for a similar level of impact in a similar habitat this is very useful in informing an assessment, particularly in relation to extent of impact and timescales for recovery. As these are both key issues that inform the level of impact on an MPA, and uncertainty around them is often part of the problem, there is a need to continue to collect targeted monitoring data on impacts and recovery in different environments.

Example:
At a windfarm site the cable route was found to go through areas of non-designated cobble reefs and micrositing was agreed around some distinct elevated cobble ridges to avoid the

worst impacts to the reef. It was necessary to go through some less good areas of potential reef and a comprehensive monitoring program was instated to look at the impact and any recovery along these areas of the cable route. In the monitoring report it is possible to clearly see the edges of the cable corridor (10-20m wide) on the multibeam, therefore it is possible to confidently ascribe 'impacted' to 'non impacted' habitat in the Drop Down Video. Assessment of the monitoring data indicated that the areas that were trenched are not expected to recover to the former habitat as it is now flat and it is possible to see patches of exposed clay in some spots. This clearly demonstrated that recovery will not take place in this kind of habitat and therefore micro siting is an important mitigation tool in such areas. What remains interesting is to what extent there will be colonisation of what currently looks a very sparse and damaged seabed, with little living there. The resulting uniformity of the seabed is leading to colonisation of communities with similar characteristics rather than the diversity that previously existed. There are patches of disturbed cobble and stone, which may be recolonized by similar species, however the exposed clay is likely to be colonised by something very different. We are interested in how this damaged habitat evolves and what it turns into physically and in terms of its biology.

<u>A13 Saltmarsh impacts</u>

These are the subject of another paper

<u>A14 Cable repairs</u>

Export and inter-array cables repairs have been necessary at a number of operational windfarms with a wide variety of impacts occurring. These can be particularly problematic where the initial works were close to causing an adverse effect or hindering the conservation objectives of an MPA and therefore any additional works are close to or may cause unacceptable impacts. At least two windfarms have found it necessary to consider fully replace their export cables. One of the key impacts that should be taken into account in assessing cable repairs/ replacement is that of repeated disturbance to the habitat (or species), thus hindering and impeding timescales for recovery or causing additional disturbance to an area that has recovered. Whilst these impacts may be within the footprint of those that occurred during construction they are additional and therefore need to be assessed cumulatively.

At 12 operational windfarms long term maintenance marine licenses have been granted for emergency cable repairs. This enables a certain number of cable repairs to be carried out using the specified methodology within the remaining lifetime of the project (usually 10-25 years). This demonstrates the operator's opinion that cable repairs are likely and indeed a number of repairs have been carried out under these licenses since they were granted. As part of the long term maintenance license applications, impacts on the marine environment from the proposed number of repairs are fully assessed, with Habitats Regulations or MCZ assessments where required, and conditions applied where necessary for mitigation. All long term maintenance licenses have a 5 yearly review period as a condition enabling a review of what works have taken place under the license and whether there have been any changes that may require modification of the license. Whilst this has been necessary for early developments, those that are going through consenting now should thoroughly assess the impact of cable repairs and replacement, in order for an assessment to be complete and the full impacts of the project to be considered at the time of application. As stated in the

Offshore Wind Programme Board paper '*Contingency plans to cover critical paths in the installation process should be incorporated into the overall execution plan. This includes not only contingency timelines, as mentioned in the previous section, but also operational contingency plans, such as for cable abandonment and cable repair.*'

In a recent marine license application a windfarm has submitted a request to repair 4km of cable immediately after installation. This may increase impacts as where there is disturbed ground they may choose to cut the cable off and install a new section alongside increasing the impact. If immediate repairs are thought to be necessary then their impacts should be assessed as part of the application along with all other impacts of installation, repair and maintenance.

10. Annex 2: Cable protection

Natural England have ongoing concerns around the use of cable protection in the marine environment. We are lacking in data regarding the full extent of cable and scour protection within the marine environment both within and outside marine protected areas and the potential impacts of this on the natural functioning of the environment. In addition there is little coordination of the data on the amount and location or cable and scour protection installed in relation to that consented across all industries. Natural England is concerned about the levels of existing and proposed scour and cable protection because the environmental impacts include;

- Loss of/ modification to habitat through the introduction of different material
- Recoverability of soft sediment communities
- Current and tidal flow disturbance
- Interruption of and changes to sediment (bedload) transport therefore affecting both near-shore geomorphological processes and ecosystem functionality.
- Increase in scour
- Creation of a substrate for marine communities which would not naturally occur in a particular region.
- Facilitation of the spread of species associated with hard substrates around the coastline, particularly non-natives, and in response to climate change.

Within an MPA these concerns are particularly pertinent and require assessment against the conservation objectives for the site. Issues can be compounded where cable protection, that may have a relatively small footprint, impacts on features that are already under pressure due to other activities such as foundation installation, aggregate extraction and fishing. In soft sediment environments there are particular concerns around changes to natural functioning of the habitat – in harder substrates there may be more opportunity to design scour protection which functions similarly to the natural environment.

Due to a lack of sufficient information regarding rock amouring from oil and gas decommissioning in North Norfolk Sandbanks and Saturn Reef SAC, Pidduck *et al* 2017 concludes that it is not possible to quantify or qualify the movement of sandbanks around or over existing or applied rock amouring. Theoretically, the mobile sandbanks may cyclically cover applied rock armouring and there is the potential for scour to be induced if an appropriate design is not chosen. Without further information on rock berm design, monitoring studies and numerical modelling of such behaviour, the short-term and long-term implications of both theoretical behaviours are difficult to determine. The report also concludes that the effects of decommissioning methods of oil and gas infrastructure have the potential to delay or even hamper the achievement of the conservation objectives of protected features designated under the Habitats Directive (92/43/EEC) and the integrity of the designated site.

Due to the above concerns, Natural England recommends that cable protection is kept to a minimum, that any use is fully justified and that where possible consideration is given to techniques that minimise the environmental impact including the use of material similar in size and composition to the natural material (e.g. in stony reef areas) and the use of material that is removable on decommissioning. However cable protection usually defaults to rock protection (almost always granite quarried in Norway) or concrete mattressing. There remains a lack of evidence around the removability of these methods on decommissioning with different answers from different developers. Repair work on the export cable at one offshore windfarm found that the rock protecting the cable was not removable and a new section of cable had to be spliced in around the rock protected section. With concrete mattressing developers often cite degradation in the ropes and links holding the mattresses together as a potential health and safety issue and barrier to removal on decommissioning. Anecdotal evidence from developers has highlighted that mattresses are easily moved or flipped by anchors. These structures have not been designed to be removed and are expected to pose some challenges in general with area specific differences as described by Jee Ltd., Zero Waste Scotland and Decom North Sea (2016).

Additionally every effort should be made to realistically assess the need for cable protection as part of the application in order for issues to be fully considered and mitigated where necessary at consenting stage. This is also of benefit to the developer as highlighted in the Offshore Wind Programme Board Paper *'Remedial works may be needed where cable protection levels are deemed insufficient. For example, for rock placement or mattress installation work, additional permits and licenses may be required, which will take time to obtain.*' The assessment, particularly in an MPA, should use (and gather where necessary) detailed information on the substrate along the cable route to inform likely areas of insufficient burial and need for cable protection. Cable protection should then be selected that works best with and minimises impacts on the particular substrate and there should then be an assessment of the impacts of the cable protection on each habitat type/ feature. Generic assessments and licensing of total amounts of cable protection across the entire cable routes have proved unhelpful in the past and led to the need for further assessment post consent, particularly where proposals are within an MPA. Additionally in a large number of cases additional cable protection has been required post consent due to cable burial issues discussed above. Lessons should also be learnt from earlier cable installation in planning and assessing cable routes. For example experience at an offshore windfarm and nearby interconnector cable has shown that sufficient cable burial is rarely achieved in chalk. At the windfarm there was a need to install over 200km of post construction cable protection due to insufficient burial depths. The interconnector cable project has also applied for post installation cable protection that was not considered at the time of application. Subsequent to the initial draft of this document a further interconnector cable and windfarm have applied for cable protection within MPAs that was not assessed at the time of application – in both these cases the operator agreed to no cable protection in the MPA at the time of consenting and has come back with license variations to place cable protection in the MPAs, effectively rendering the original assessment and consent incomplete.

As discussed under mitigation and scour elsewhere in the document, where cable protection is needed it is also important to pay attention to the sand wave field in the area surrounding the rock armouring location. The rippling in the sand in the wider area can show how mobile is the area and the sediment transport direction. Where possible the cable protection in a dynamic environment should not be placed perpendicular to the sediment transport (i.e. the long side of the rock protection should not run at angles close to parallel with the ripple crests) as this can result is large scour pits. If this is considered necessary then the associated issues highlighted should be considered and addressed as part of the application.

11. References:

Jee Ltd., Zero Waste Scotland and Decom North Sea, 2016. Mattress Solutions

Pidduck, E., Jones, R., Daglish, P., Farley, A., Morley, N., Page, A. & Soubies, H., (2017), Identifying the possible impacts of rock dump from oil and gas decommissioning on Annex I mobile sandbanks, JNCC Report 603, ISSN 0963-8901

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