Crown Estate Scotland

Collaboration for Environmental Mitigation & Nature Inclusive Design (CEMNID)

Final Report

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XODUS

REVISIONS & APPROVALS

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1 INTRODUCTION

1.1 Background to the CEMNID Project

The twin crises of climate change and biodiversity loss are arguably the greatest environmental challenges of our era. Energy production from renewable sources (e.g. offshore wind farms) is key for reducing carbon emissions and achieving the Net Zero target by 2045 in Scotland. However, these offshore renewable developments may have adverse environmental impacts on marine species and habitats, hindering biodiversity recovery. The implementation of effective mitigation measures, as well as the development of practices supporting nature recovery present both challenges and opportunities for the sustainable development of the offshore wind sector globally.

The Scottish Offshore Wind Energy Council's (SOWEC) Barriers to Deployment – Enabling Group established the Collaboration for Environmental Mitigation and Nature Inclusive Design (CEMNID) Project to address two key knowledge gaps with regard to environmental uncertainty in relation to impacts from offshore wind developments during construction and operational phases. These gaps are:

- To identify the most appropriate mitigation measures for environmental receptors that can be applied to offshore wind developments in Scotland when applying mitigation hierarchy; and
- Identify opportunities to implement Nature Inclusive Design (NID) to Scottish offshore wind projects in order to contribute to biodiversity enhancement and nature-positive outcomes from such developments.

It is recognised that a key barrier to the consenting and deployment at pace of offshore wind farms is environmental uncertainty, including in relation to impacts from developments during construction and operational phases and the efficacy of environmental mitigation and enhancement measures such as Nature Inclusive Design (NID). These uncertainties directly contribute to risks and delays in the consenting and deployment of Scottish offshore wind developments and therefore threaten the achievement of Scotland's net zero and nature positive targets. Dealing with these uncertainties also exacerbates resourcing pressures across the consenting system for developers, regulators, advisory bodies and NGOs, increases development costs and risks irreversible wildlife losses. To accelerate consenting and facilitate the sustainable and rapid expansion of offshore wind deployment in Scotland, environmental uncertainties associated with offshore wind development therefore urgently need to be addressed.

By addressing the above mentioned gaps, the CEMNID Project seeks to develop a holistic framework to identify and apply good practice environmental mitigation and to provide some understanding of how to deliver environmental benefit through embedding NID in Scottish offshore wind development projects. This will help address key barriers to consenting and deployment and will support Scottish offshore wind projects to tackle the climate and nature crisis in tandem.

The overarching objectives of the CEMNID Project are therefore to:

- Provide a clearer understanding of how to apply the mitigation hierarchy in offshore wind development, including consideration of embedded measures and design decisions;
- Summarise good practice environmental mitigation measures available to deploy through the mitigation hierarchy;

- Identify the principles of NID for offshore wind development, including how these relate to the mitigation hierarchy;
- Identify ecologically promising and practically applicable NID measures that could be applied to Scottish offshore wind projects; and,
- Provide evidence to support the consenting requirement to implement nature-positive development in the marine environment and thereby comply with the adopted National Planning Framework 4 and emerging policies including National Marine Plan 2.

The CEMNID Project is overseen by a steering group comprising technical and consenting experts drawn from offshore wind developers, consultees and regulators. The Project secured funding from Crown Estate Scotland and approval from SOWEC, resulting in Xodus Group Limited (Xodus) being commissioned to deliver the Project scope in line with the objectives. This document has been prepared by Xodus with input from the Rich North Sea.

1.2 Aims of the Report

This Final Report aims to provide offshore wind developments in Scotland (with a focus on ScotWind option areas) with a framework to make informed decisions regarding:

- Applicability of the mitigation hierarchy and good practice mitigation measures to be adopted for projects, as demonstrated by the Good Practice Library (see Section 2); and
- Initial advice, and a framework for consideration of NID approaches, that can be implemented by individual offshore wind projects (see Section 3).

This Report also outlines the key challenges, limitations and data gaps noted by the CEMNID Project and importantly provides key recommendations for future work needed to build on the findings from this Project.

1.3 Outputs of the CEMNID Project

To facilitate the CEMNID Project, several key deliverables have been produced as shown in Figure 1 and described below:

- Mitigation Measures Literature Review (A100906-S00-A-REPT-002):
  - Literature review and associated research regarding the use of environmental mitigation measures for Scottish and other relevant offshore developments which, based on objective criteria, are considered to represent good practice;
- NID Literature Review (A100906-S00-A-REPT-003):
  - Literature review and associated research on international evidence of NID approaches which are assessed as ecologically promising, practically applicable, and relevant to offshore wind deployment in Scotland;
- Mitigation Measures Efficacy Review and Good Practice Library (A100906-S00-A-REPT-004):
  - Development of a Good Practice Library for environmental mitigation and an associated efficacy review for a subset of key measures;
- NID Suitability Review and SWOT analysis (A100906-S00-A-REPT-005):

  - Strength, Weaknesses, Opportunities and Threats (SWOT) feasibility analysis of identified options for their applicability to offshore wind in Scotland, and associated NID suitability review focusing on ScotWind option areas and supporting infrastructure corridors to determine habitat and species suitability;
- Final Report (current deliverable; A100906-S00-A-REPT-007):
  - Structured report including discussion of mitigation good practice and guidance on implementing NID at a project level.

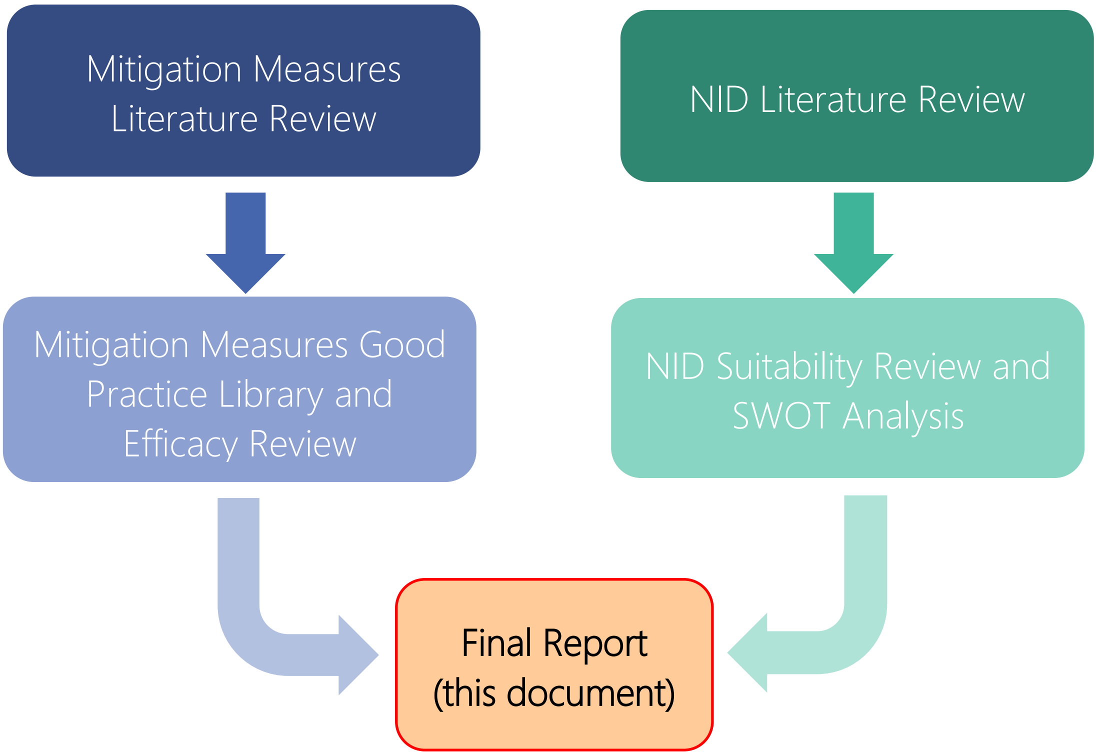

Figure 1 CEMNID Deliverables

Each of these deliverables should be read in conjunction with this Final Report (A100906-S00-A-REPT-007).

2 GOOD PRACTICE MITIGATION MEASURES

2.1 Introduction

As set out in Section 1.2, a primary aim of the CEMNID Project was to identify mitigation measures applicable to Scottish offshore windfarm developments which could be considered representative of good practice and which can be compiled into a Good Practice Library of mitigation measures. It is therefore important to define what is meant by good practice. Good practice can be defined as “a process or methodology that has been consistently shown to work well and to achieve reliable results" (IEEM, 2021). In order to identify mitigations that were deemed to be examples of good practice, a series of complementary deliverables and actions were undertaken by the CEMNID Project (in Table 1), culminating in the development of a Good Practice Library.

Table 1 Overview of CEMNID actions and deliverables with regards to mitigation measures

CEMNID ACTION	CEMNID DOCUMENT	WHERE SUMMARISED IN THIS DOCUMENT
Literature review of mitigation measures for offshore wind	Mitigation Measures Literature Review (A100906-S00-A-REPT-002)	Section 2.2
Stakeholder engagement		Section 2.4
Efficacy review of a subset of selected mitigation measures	Mitigation Measures Efficay Review (A100906-S00-A-REPT-004)	Section 2.5
Development of a Good Practice Library	Good Practice Library	Section 2.6

2.1.1 Mitigation Hierarchy and Mitigation Categories

A key guiding principle for identifying suitable mitigation measures was to consider the mitigation hierarchy (Figure 2), especially the concepts of avoidance and minimisation. The CEMNID Project did not consider restoration or offsetting measures within its scope.

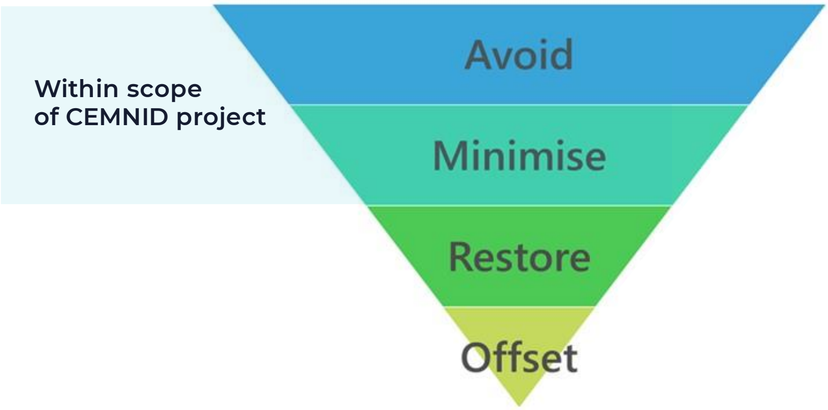

Figure 2 Mitigation hierarchy as applied in CEMNID Project

The mitigation hierarchy is organised in order of 'preferred' approach, starting with avoidance. The definition of avoidance and minimisation is outlined in Table 2.

Table 2 Definitions used in the mitigation hierarchy (adopted from The Biodiversity Consultancy, 2024)

MITIGATION TYPE	DEFINITION
Avoidance	The first step of the mitigation hierarchy comprises measures taken to avoid creating impacts from the outset. This may include careful placement of infrastructure or timing construction sensitively to avoid disturbance. Avoidance is often the easiest, cheapest and most effective way of reducing potential negative impacts, and it requires biodiversity to be considered in the early stages of a project. These will typically be primary and tertiary mitigations.
Minimisation	Measures taken to reduce the duration, intensity and/or extent of impacts that cannot be completely avoided. Effective minimisation can eliminate some negative impacts, such as measures to reduce noise and pollution, designing powerlines to reduce the likelihood of bird electrocutions, minimising habitat modification by reducing the quantity of rock required to protect an underwater cable or building wildlife crossings on roads. Minimisation measures can be either primary, secondary or tertiary mitigations.

Avoidance measures should be considered first and incorporated where possible within a project design, and as early in the project cycle as possible. Avoidance measures are generally primary mitigation measures that will be factored into early project design. Such measures include, but are not limited to, avoidance of siting infrastructure on sensitive features such as biogenic reefs, construction alternatives to impact piling, avoidance of Unexploded Ordnance (UXO) detonation, and timing project construction to avoid particularly sensitive periods of a receptor (e.g. breeding/spawning season). In some cases, the need for avoidance mitigation may not be apparent until adequate environmental baseline data has been acquired for the site.

Where the risk of impact from an activity cannot be reasonably or completely avoided, the next step is minimisation. Minimisation can be either primary or tertiary and both are construed to be embedded in project design when captured early during the pre-consent phase. Descriptions of mitigation categories are shown in Table 3. If, despite the application of primary mitigation measures, residual impacts are still significant, secondary minimisation impacts can subsequently be adopted. It is important to note that the application of the mitigation hierarchy follows the precautionary principle, under the United Nations Rio Declaration (UN, 1992).

Table 3 Definition of mitigation categories (adopted from IEMA, 2016)

MITIGATION CATEGORY	DESCRIPTION
Primary (inherent)	Primary mitigation is an intrinsic part of the project design and should be described in the design evolution narrative and included within the project description. For example, reducing the height of a development to reduce visual impact.
Secondary (foreseeable)	Secondary mitigation requires further activity in order to achieve the anticipated outcome – typically, these will be described within the topic chapters of the ES, but often are secured through planning conditions and/or management plans. For example, description of certain lighting limits that will be subject to submission of a detailed lighting layout as a condition of approval.
Tertiary (inexorable)	Tertiary mitigation will be required regardless of any EIA assessment, as it is imposed, for example, as a result of legislative requirements and/or standard sectoral practices. For example, the adherence to JNCC seismic survey guidelines for minimising the risk of noise to marine mammals. .
Embedded Mitigation	Embedded mitigation considers both primary and tertiary mitigation on the basis that both these forms of mitigation definitely will be delivered: thus, any effects that might have arisen without these forms of mitigation do not need to be identified as 'potential effects'.

It is important to note that applying the mitigation hierarchy should be considered against three different categories of mitigation, namely primary, secondary and tertiary mitigation. Primary mitigation measures incorporated into design will typically reflect avoidance and minimisation measures that can be committed at the early stage of a project. Similarly, tertiary mitigations will relate to avoidance and minimisation measures driven by policy, industry guidelines and accepted standard practices and if adopted, will become embedded in a project's Environmental

Management Plan (EMP). In the case of secondary mitigations, these can be incorporated to further minimise impacts where the application of primary and tertiary measures are deemed to be insufficient to reduce the environmental risk to acceptable levels. These secondary mitigation measures will depend on the specific development and the sensitivities of the receptors present. For this reason, a particular mitigation measure could be a primary or secondary mitigation, depending on the project circumstances (e.g., physical controls including modification to standard infrastructure such as minimum air gap between turbine blades and sea surface).

Primary and tertiary mitigations can be considered to comprise 'embedded mitigation' (sometimes referred to as 'mitigation by design'). Embedded mitigation is considered mitigation that can be incorporated and committed to at the early design stages of a project and may be firmly incorporated into the windfarm design, such as the commitment to a specific minimum turbine air gap (turbine blade tip to sea clearance), turbine spacing, avoidance of protected areas or features and avoidance of intertidal interactions through horizontal drilling of cables at landfall. In addition, embedded mitigation may be an early commitment that will be driven by tertiary mitigation such as a procedure that will be followed during construction activities e.g., following JNCC protocols for soft start piling, or the development of an Invasive Non-Native Species (INNS) management plan, which would be further developed and implemented in the post consent phase of the project. It is important to note that embedded mitigations include design measures that were driven by engineering requirements that also consequently have environmental benefits and can be considered good practice where these can be deployed. Examples of these are alternative foundation installation to piling (i.e. avoiding high-amplitude underwater sound emissions which could affect acoustically sensitive species) or cable burial/protection material that also doubles up as protection from electromagnetic fields (EMF), by increasing the separation between the source and receptor. It should also be considered that ongoing monitoring can enable the possibility of adaptive mitigation if required throughout the operational phase of the project life cycle.

2.2 Challenges, Limitations, and Data Gaps

The literature review of mitigation measures covered a wide variety of sources including policy and guidance documents, project specific documents (especially EIA scoping reports and EIARs), monitoring reports and scientific literature. However, this widespread approach meant that a comprehensive review across all available project specific documentation (including post-consent planning documents, protocols, environmental management plans, and consent conditions) was not undertaken, primarily due to time constraints. Key information relating to mitigation measures was extracted where deemed relevant such as piling strategies, where this supplemented the existing understanding. However, it should be made clear that this was not comprehensively covered in the review. The long-list of good practice mitigation measures was informed by a review of 11 offshore wind farm EIARs, and seven EIA Scoping Reports considered to represent a range of fixed and floating designs covering the breadth of commercial-scale and demonstrator projects across Scotland.

With regards to monitoring reports there were limited project examples. Six projects were reviewed in total for which environmental monitoring reports were assessed (four Scottish and two from the rest of UK) which provided indicative information of the resultant condition of receptors following installation.

A further limitation was the current small number of operating windfarms in Scotland. It is recognised at the time of writing that more monitoring outputs are expected to be available imminently, in addition to a range of scientific research projects capitalising on the operational phase of offshore wind developments (e.g. the PrePARED[1] and PELAgIO[2] projects) and together these studies will add to the body of evidence acquired in the CEMNID Project. As the industry matures, this data set will become much more robust, further solidifying confidence in existing data and modelling predictions used in impact assessments. An acknowledgement should be made to the Regional Advisory Groups (RAGs) for the Moray Firth and Forth and Tay offshore wind regions, and the Offshore Wind Evidence and Knowledge Hub (OWEKH) where such collaborative data is shared.

Tthe Scottish Marine Energy Research (ScotMER) programm has created evidence maps to highlight data gaps across a number of key receptor groups (including ornithology, marine mammals, fish, benthic, physical processes; Scottish Government, 2024). The evidence maps highlight that data sets must be acquired over appropriate timescales in order to understand the ecological effects of offshore windfarms on these receptors. Data sets spanning longer timeframes can help to more accurately predict and quantify receptor responses to the effects of offshore windfarms and also better understand ecosystem dynamics, such as predator-prey relationships. As acquisition of more data through post-construction monitoring is acquired, analysed and made more widely available, a more complete picture of overall effects both on a project level and a larger cumulative scale can be derived. Therefore, it should be recognised that any indications of the apparent effectiveness (or not) of mitigation measures derived from project monitoring and summarised in this report should be considered tentative. Overall, there was no evidence to suggest that any of the deployed mitigations for the projects included within the review were ineffective. It is tentatively concluded that the measures that have been deployed in those projects are representative of good practice in the offshore wind industry in Scotland, with the important caveat that these measures should be considered on a case by case basis and will not always be appropriate for a given site or development type.

The Good Practice Library is intended as a starting guide to help offshore wind developers identify key good practice measures that may apply across the life of the development. The mitigation measures presented in the library follow the mitigation hierarchy which takes a cautious approach by taking the sequence of steps of avoidance and minimising to reduce impacts. It is based on the information derived from the CEMNID Project and due to the limitations in these data outlined above, is not considered to represent a fully comprehensive, exhaustive list of mitigations that may be available for all development scenarios which will be dependent on design parameters and site-specific sensitivities.

The Good Practice Library points to key mitigations that are generally acceptedand known to have a level of effectiveness at the time of writing and are tried and tested in Scottish waters. However, the intention is not to rule out emerging technologies which may be data deficient at the time of writing but may become best practice in the future when more robust information on the efficacy becomes available. Similarly, changes may be made as monitoring and the additionality of data reveals existing screened-in measures are no longer deemed effective. Therefore, the Good Practice Library will need to be updated as more information becomes available.

The Library does not aim to preclude adaptive management principles that may be informed by ongoing monitoring for a particular development. The user of the Library should be aware of these limitations with future developments considering whether other (e.g. novel) approaches could also be applied.

[1] https://owecprepared.org/
[2] https://ecowind.uk/projects/pelagio/

2.3 Mitigation Measures Literature Review

The literature review of mitigation measures focussed specifically on mitigations relating to environmental receptors (both biotic and abiotic). The review drew on a wide range of source material including the following:

- National guidelines on mitigation (e.g. UK policy statement, JNCC protocols);
- International guidelines on mitigation (e.g. IUCN, Australian government and ACCOBAMS);
- Publicly available UK impact assessment scoping reports and Environmental Impact Assessment Reports (EIARs) – with a focus on Scottish projects;
- A review of published outputs from research groups such as the offshore wind Regional Advisory Groups (RAGs) in Scotland;
- Scientific literature relating to relevant offshore wind mitigations;
- Publicly available monitoring survey reports from offshore wind farms in the UK; and
- Consideration on how mitigations from other offshore industries may apply to offshore wind.

Further detail on the review process can be found in the Mitigation Measures Literature Review (A100906-S00-A-REPT-002).

The literature review examined sources of information such as UK and international policies, mitigation measures in EIARs and EIA Scoping Reports as well as innovative/novel mitigation measures proposed from international groups of experts. The review compiled information on mitigation measures across a range of environmental receptors (e.g. physical environment, water and sediment quality, benthos, fish and shellfish, marine mammals, offshore and intertidal ornithology). For each mitigation measure identified, information was provided about which level of mitigation hierarchy applies, the project phase during which the measure is considered, and which projects have proposed or implemented the measure.

One of the key outcomes was that early stakeholder engagement was particularly important. This enables sensitivities and appropriate mitigation to be realised at an early stage of development. Consultation throughout the impact assessment process enables the identification and refinement of mitigation measures that are specific to the environmental receptors. Apart from early engagement, the importance of openness/transparency was highlighted for its role in facilitating the implementation of mitigation measures. Early consultation and consideration of avoidance mitigation in the early planning phases can significantly improve the environmental performance of a project (as well as realise cost savings and help deliver a smooth consenting process). On the contrary, late stakeholder engagement can significantly reduce the capacity to implement further mitigation into the design.

The review also showed that many of the mitigation measures proposed were primary mitigation measures that were inherent in the design of the development and/or a consequence of standard practice (e.g. cable burial, minimising rock protection, turbine spacing). In some of these cases, where these mitigation measures are proposed, the driver is most often engineering design and/or cost effectiveness rather than the environmental benefit. Nonetheless, some of these measures were also considered to represent good practices that generally result in some environmentally beneficial outcome. It is proposed that retaining these measures as good practice examples of embedded environmental mitigation will help to ensure such measures are committed and carried through to executing the project.

A key emerging finding in compiling the list of mitigation measures across EIA Scoping Reports and EIARs was that the embedded mitigations included were predominantly in line with existing, established guidance and policy criteria for offshore wind developments in UK/Scottish waters. As such, it is proposed that these embedded measures would generally be considered as good practice measures for environmental mitigation. Avoidance mitigation measures identified in the literature review were generally applicable to both fixed and floating designs and thus considered appropriate to the range of ScotWind and other Scottish offshore wind projects going forward.

The implementation of the mitigation hierarchy can also be applied in the consideration of innovative/novel mitigation measures identified in the literature review. For these innovative/novel mitigation measures, information on the mitigation level that they apply to (e.g. minimisation), project stage (e.g. construction/installation) as well as on their efficiency or efficacy (e.g. level of noise reduction) were provided. As many of these measures have generally not yet been tested in Scotland, especially on a commercial basis in the context of offshore wind, their effectiveness and applicability to the region is somewhat unknown. This is especially true when considering additional noise abatement options that go beyond the standard protocols for piling that are current standard practices, such as the use of measures to reduce sound emissions at source or alternative methods of driving piles.

However, it remains plausible that some of these alternative mitigation measures may have real potential and they could be incorporated into a suite of good practice measures to be considered for offshore wind in Scotland. It was considered that measures for noise abatement such as Big Bubble Curtains and Hydro Sound Dampers (HSD) have promise for applicability in Scottish waters and should provisionally be considered for incorporation into the Library of best practice, particularly as supplementary mitigation for UXO clearance. It is anticipated that more novel noise abatement measures specific for piling that have been tried and tested in shallower waters (<40 m), especially in Europe, may not be suitable in Scotland (Verfuss *et al*., 2019). While there is potential some of these measures may be modified to be effective in deeper water, the review found no *in situ* evidence as yet to support this. Subsequently, the most promising of these measures were tentatively included in the Good Practice Library with the recommendation that if such measures were adopted that they should be supported with a suitable monitoring plan that would help to bridge the data gap. In future, measures may be screened again and incorporated into the Library if they are found to be effective and technically viable for Scottish offshore windfarms. As such it is important to understand that just because a measure is not included in the Good Practice Library at present, it does not necessarily mean it should be disregarded and that that there is no merit in its application in certain circumstances.

A relatively recent example of adoption of newer measures is that of low order deflagration for UXO. Low order deflagration for UXO has recently been successfully deployed, monitored and reported from a Scottish site (Moray West windfarm) and is therefore a proven method that generates considerably lower noise than a controlled UXO detonation (Nuria Abad *et al*., 2024). The use of low-noise alternatives to detonation of UXO has been incorporated into UK guidance through a joint statement produced by regulators and statutory nature conservation bodies (UK Government, 2022).

Seabird collision risk mitigation measures, such as remote sensing detection coupled with shutdown/slowdown technologies, or the painting of turbine blades, may have the potential to significantly reduce impacts of ScotWind projects where sensitivities of seabirds are particularly high. However, at the time of writing these technologies have not been identified or incorporated into windfarms deployed in Scotland and given the uncertainty of effectiveness and applicability, these measures were not carried forward into the Good Practice Library.

A key point that emerged both from the stakeholder engagement and the literature review on mitigation is the need for a holistic overview of the mitigation measures considered on a case-by-case basis. Each mitigation measure should not be regarded in isolation as a measure that solely reduces negative effects on a specific receptor; it may also result in unintended consequences. This finding is relevant to both innovative/alternative measures as well as to standard practices. For example, painting turbine blades black to avoid collision risk with seabirds may have negative impacts on the landscape due to increased visibility. Another example relates to commitments around setting a conservative target cable burial depth which may end up in a situation that requires additional rock protection to meet the commitment, which would result in additional physical impacts to the seabed. Also, the use of acoustic deterrent devices (ADD; an underwater noise mitigation that is commonly implemented to actively displace marine mammals from the zone experiencing the highest amplitude sounds during construction) may also have some associated negative impacts on marine mammals through the introduction of another noise source into the marine environment. These points emphasise the need for a more holistic consideration for mitigation measures across multiple receptors.

Advancing our understanding on how to apply the mitigation hierarchy may also benefit from knowledge gathered from other industries (e.g. oil and gas, shipping, aquaculture). In the view of other industry learnings, the offshore oil and gas industry, in particular, can be drawn from decades of experience gained through various project stages (from installation and construction through to decommissioning). There are parallels that have been identified with regard to design and removal considerations for Floating Production Storage and Offloading units (FPSOs) and floating wind structures for instance (both moored with complex anchoring systems) as well as the parallels between pipeline and cable installation considerations with regards to approaches for mitigation and monitoring.

The literature review has also summarised key findings from monitoring reports carried out prior to, during, and after the construction of offshore wind developments. It is acknowledged that disentangling the role of mitigation measures themselves on the ecological status of environmental receptors is challenging. Even under these circumstances, however, it is regarded that the outcomes of these monitoring reports can advance understanding about how and when to apply good practice mitigation. For example, post-commissioning survey monitoring results would generally appear not to show significant changes from baseline conditions. One of the mitigation measures that seems to be successful so far for mitigating impacts on some seabird species (based on available monitoring data) is the application of a minimum air gap between rotor blades and sea surface. This measure has been mentioned in several EIARs as well as evidenced through the Aberdeen Bay and Robin Rigg offshore wind farm post-construction and operational monitoring outputs. It is important to note though that these results are specific to the design parameters and sensitivities of the specific windfarms so there is no 'one size fits all' solution.

2.4 Stakeholder Engagement

Throughout the CEMNID Project, stakeholder engagement has been a crucial element in supporting the development of the deliverables (as detailed in Section 1.3).

With regards to mitigation measures, informal discussions were held with stakeholders involved in Scottish offshore wind. During December 2023 and January 2024, Xodus held a series of informal discussions with key stakeholders involved in the field of offshore wind in Scotland (Marine Directorate Licencing and Operations Team (MD-LOT), NatureScot and numerous offshore wind developers). The main aim of these informal discussions was to identify key parameters that support or hinder the success of environmental mitigation measures for the offshore wind sector in

Scotland. The key outcomes of these discussions are discussed in full in the Mitigation Measures Literature Review (A100906-S00-A-REPT-002) but are summarised here in Table 4.

The engagement of the CEMNID Project with MD-LOT, NatureScot and offshore wind developers played an important role in the identification of parameters that contribute to a clearer understanding of how to apply the mitigation hierarchy in offshore wind development. This engagement identified parameters that facilitate or hinder the success of mitigation measures. For example, the Project has highlighted the importance of early consultation and engagement of offshore wind developers with stakeholders. These early discussions should incorporate considerations of potential significant effects and what can be done to mitigate them to enable primary mitigations to be recognised and embedded within the Project Design Envelope (PDE). Design parameters such as minimum air gap between the sea surface and blade tip and placement of site boundaries that avoid protected areas are considered truly 'designed-in' or primary mitigation measures that can be incorporated into early design.

Outputs from the informal stakeholder discussions have been considered in the delivery of the Mitigation Measures Efficacy Review (A100906-S00-A-REPT-004) and the Good Practice Library (see Sections 2.5 and 2.6).

Table 4 Summary of key themes resulting from stakeholder discussions

FACTORS CONTRIBUTING TO SUCCESSFUL MITIGATION	FACTORS THAT HINDER SUCCESSFUL MITIGATION	FACTORS FOR FURTHER CONSIDERATION
• Early and ongoing engagement • Maintaining design flexibility • Openness and transparency between developers and regulators/SNCBs • Willingness to innovate	• Lack of certainty in project design • Lack of monitoring of mitigation measures, in particular those where there is no clear correlation with reduction of impact at source • Contract competition • Potential extra costs of mitigation • Uncertainty in feasibility	• Testing of efficiency of innovative measures • Holistic consideration of mitigation measure effects • Regulatory process that drives environmental recovery and restoration

2.5 Summary of Mitigation Measures Efficacy Review

One of the aims of the review of mitigation measures was to determine the efficacy of a key subset of measures relevant to offshore windfarms in Scotland. The measures that were subject to further review as part of the Mitigation Measures Efficacy Review (A100906-S00-A-REPT-004) encompassed mitigations relating to underwater noise, collision risk with birds and EMF, as listed below:

- Underwater noise;
  - Use of Acoustic Deterrent Devices (ADDs);
  - Lift and Relocate of UXOS;

  - Low noise clearance of UXO;
  - Low noise foundation installation methods;
  - Bubble curtains and alternative noise abatement methods;
- Collision risk with an emphasis on birds;
  - Consideration of turbine layout;
  - Maintenance of minimum turbine air gap;
  - Consideration of alternative mitigation methods (e.g. shutdown systems);
- Mitigations associated with disturbance and displacement;
  - Minimisation of offshore lighting;
  - Control of vessel movement and lighting; and
- Effects of EMF on marine life.

Most of the information on effectiveness of measures came from research on specific mitigation methods rather than commercial scale monitoring reports. It was not possible to meaningfully review the efficacy using monitoring survey data (pre-constructions, during construction and post construction) drawn from the literature review as this was relatively short term (one or two years post-construction) and generally inconclusive in determining whether a deployed minimisation mitigation measure itself was effective or not (largely due to monitoring being directed at receptors and not mitigation measures). Tentative conclusions that there was no evidence of significant impacts on key receptors including birds, cetaceans and benthos could be made based on monitoring of these receptors. Furthermore, existing, well established mitigation protocols such as following JNCC protocols for soft start piling which are known to be effective in reducing risk to marine mammals.

There were some emerging noise abatement systems (NAS) which have been successfully deployed in Europe but are not, as yet tested in Scottish waters. These were primarily related to piling noise mitigations such as resonator systems and bubble curtains and other barrier type devices that had proven effectiveness in relatively shallow waters (<40 m). To date, there is some uncertainty over the applicability of such devices in deeper waters where many Scottish offshore windfarms are likely to be constructed. However, it was still considered that some additional noise abatement measures such as resonator NAS systems for piling applications and bubble curtains could be utilised as complementary mitigation along with existing good practices for UXO clearance such as low order deflagration or controlled detonation.

The efficacy of mitigation measures relating to collision risk included in the Library takes into account *in situ* adjustments of project design parameters (such as offshore turbine layout and minimum air gap) in relation to their potential impacts on collision risk for seabirds. In 2019, the amended impact assessment for seabird collision risk at the Norfolk Vanguard Offshore Wind Farm considered a revision of wind turbine layout and situation within the project area. The assessment, although site specific, concluded that these updates would reduce collision mortality of all species assessed by 34% compared to the findings of the initial Environmental Statement (MacArthur Green, 2019). Further to an update to turbine layout, the turbine air gap within the Norfolk Vanguard Offshore Wind Farm was increased from 22 m to 27 m, resulting in the average collision risk (across species) for the project reducing by 65% compared to the findings of the original Environmental Statement, based on collision risk modelling (MacArthur Green, 2019). It is important to note that such results are likely to be influenced by geographic location, proximity to seabird population centres, and species.

The efficacy of mitigation measures included in the Library relating to disturbance and displacement considers the impacts of infrastructure and vessel lighting on seabirds through both *in situ* assessment and modelling outputs. There is existing evidence to suggest that the selection of lighting colour, angle and mode on offshore infrastructure has the potential to reduce disturbance and/or displacement impact for seabirds, with demonstrable evidence of the effectiveness of down-lighting shields on bright lights for nocturnally flying birds (Poot *et al*., 2008). Furthermore, the methodology of only illuminating WTGs when the associated airspace and marine space is occupied (as applied to German installations) demonstrated a reduction in aviation lighting by 99% (Defingou *et al*., 2019). Modelled results and behaviour data into light mitigation for project vessels concluded that mitigation measures such as establishing what level of vessel lighting are required for different marine environments and where it might be possible to operate a 'dark ship' proved effective for minimising disturbance and displacement to seabirds (Goad *et al*., 2023). Despite evidence of seabird disturbance and displacement from an area as a result of the physical presence of lighting associated with offshore infrastructure and project vessels, further research suggests that the effects of displacement from a single, small-scale offshore wind farm and associated vessel operations may be minor, owing to the highly mobile nature and wide-spread distribution of seabirds (Croll *et al*., 2022). It is therefore considered that displacement effects could become more severe in the presence of a larger offshore wind array, where the energetic cost of avoiding the WTGs may be greater, or where a project and associated vessel movements act cumulatively with another offshore development within the marine environment (Croll *et al*., 2020).

The efficacy mitigation measures included in the Library relating to EMFs consider both *in situ* assessment and modelling outputs. One particular study into the influence of subsea cables and associated EMF on the receiving environment concluded that the level of exposure to EMF exposure for key receptors was influenced by the depths at which the cable was buried and the position of the animal within the water column (Hutchison *et al*., 2021). Available *in situ* EMF emissions from subsea cables demonstrate a rapid decrease in the strength of the magnetic field with distance from the cable, the zone affected decreasing significantly in areas where the cable is buried or additional cable protection is applied (i.e., where there is no exposed cable laid directly on the seabed) (BOEM, 2023; Hutchison *et al*., 2020). There remains uncertainty into the potential impacts of EMFs on ecological receptors , with the need for further *in situ* EMF measurements and environmental monitoring required before a more detailed understanding of the potential impacts of EMF can be described.

2.6 Mitigation Good Practice Library

The mitigation measures that were listed for potential consideration into the Good Practice Library were drawn from the measures identified in the literature review. These included measures which were initially implemented as a consequence of engineering/design requirements and had incidental positive benefits. While these benefits may be consequential, they can represent good practice from an environmental perspective, nonetheless.

A mitigation measures 'long-list' was screened against objective criteria that helped determine whether the identified mitigation was representative of good practice (i.e. that can consistently be shown to work well and achieve reliable results). To this end the objective screening was undertaken using two key differentiators in the following order:

1. Is the mitigation measure included in UK policy and/or routinely used as Current Industry Practice?
2. Has the measure been technically proven to be applicable to Scottish offshore waters?

The principles of the first criteria were applied on the assumption that existing practices and policy drivers are grounded and based on best available knowledge on receptors with reasonable evidence based on experience that they are effective. In the absence of any information to indicate otherwise, it was assumed that mitigation measures meeting these criteria were effective and produced reliable results. A third criterion considered 'unintended consequences' associated with each mitigation measure (if applicable). However, while these unintended consequences were noted in the screening process, this criterion was not used as a differentiator for screening in/out any particular mitigation measure. Unintended consequences of mitigation are discussed further in Section 2.3.

The Good Practice Library is presented in an Excel spreadsheet which contains three worksheets.

- Worksheet 1 – User Guide
- Worksheet 2 – Screening
- Worksheet 3 – Good Practice Library

The user guide includes the principles of the screening method that utilised a traffic light screening (red, amber, green) based on the objective criteria discussed above for scoping in or out a measure. In applying the screening, it was not deemed necessary that both criteria had to be met in order to be screened in and it was also considered in the screening that a mitigation was clearly 'yes' or 'no' to either, so there was allowance made for partially meeting the criteria which was assigned an amber rating. More information on the definitions and rationale are included in the Library itself.

The Good Practice Library lists the following information against each screened in mitigation measure:

- Infrastructure type (fixed, floating and cables);
- Project phase (i.e. early design, construction, operation, decommissioning);
- Mitigation hierarchy (avoidance or minimisation);
- Mitigation type (primary, secondary or tertiary); and
- Receptors affected (physical processes, sediment/water quality, benthic, fish and shellfish, mammals and birds).

The definitions of the various parameters listed above are included in the Good Practice Library User Guide (Worksheet 1).

It is intended that by assigning this information to a particular measure in the Library, the filters in each column can help to identify appropriate mitigations to a particular scenario, design type, or receptor, and help to identify whether this could be incorporated into early design phase as embedded mitigation.

Though the Good Practice Library does detail a number of mitigation measures that could be considered for a windfarm, it is important to note that their applicability may depend on project specific conditions and requirements. Furthermore, the Library is not considered to be an exhaustive list, rather a starting point and there is opportunity for addition of new measures and subsequent revision of existing measures. Similarly, the Library represents a snapshot in time – as technologies emerge or change over time, so too might mitigation measures. Beyond this, political landscapes and use of marine resources may change over time such that mitigation measures may need to be adapted accordingly. The mitigation measures in the Good Practice Library apply the mitigation hierarchy and promote a precautionary approach. However, it should be noted that this systematic process does not necessarily reduce uncertainty but should instead support advancement of understanding that can drive adaptive management, as pointed out in the State of Science Report (OES-Environmental, 2020). These learning and associated adaptive mitigations can be supported by ongoing monitoring at a site specific level. Consequently, it is proposed that the Good Practice Library is consulted with this limitation in mind.

3 CONSIDERATION OF IMPLEMENTATION OF NATURE INCLUSIVE DESIGNIN SCOTLAND

3.1 Introduction to NID

One of the themes central to the CEMNID Project was to identify NID measures in offshore wind which may be suitable for application in Scotland, particularly with respect to ScotWind. To do this, a literature review was conducted to synthesise available information on NID. This information led to the formation of groups of NID options, which were then subject to SWOT analysis. The SWOT analysis of the NID groups included input from stakeholders. This information was synthesised and then, based on an understanding of the Scottish environment, the applicability of NID to Scotland and ScotWind was determined in the NID Suitability Review.

These supporting actions and deliverables are outlined in Table 5 and are summarised and referred to throughout the subsequent sections.

Table 5 Overview of CEMNID actions and deliverables with regards to NID

CEMNID ACTION	CEMNID DOCUMENT	WHERE SUMMARISED IN THIS DOCUMENT
Literature review of NID in offshore wind	NID Literature Review (A100906-S00-A-REPT-003)	Section 3.3
SWOT analysis of NID options	NID Suitability Review (A100906-S00-A-REPT-007)	Section 3.4
Stakeholder engagement workshops		
Review of NID suitability in Scottish offshore wind		

3.1.1 The Role of NID in the Context of Mitigation

The CEMNID Project defines NID as measures which are either integrated into the design of an offshore structure or incorporated as a standalone unit within the windfarm design as a whole, with the specific aim of supporting species or species groups, or enhancing species richness. Ultimately, NID aims to support biodiversity enhancement and nature positive outcomes. In Scotland, appropriate selection and integration of NID options may be of benefit to Priority Marine Features (PMFs), while simultaneously complying with, or contributing to, objectives within the framework of the European nature protection legislation.

In the context of the mitigation hierarchy, shown in Figure 2, NID broadly falls between minimisation and restoration but may also include aspects of offsetting. As detailed in Section 2, avoidance and minimisation mitigation measures are the focus of the Good Practice Library. While the mitigation hierarchy does include habitat rehabilitation and offsets, the CEMNID Project has opted not to incorporate restoration/enhancement options, following advice from the PSG members.

3.2 Challenges, Limitations, and Data Gaps

As noted in Section 2.1.1, while it is acknowledged that work on restoration and enhancement has gathered pace recently, from individual projects to potential indicators of policy and legislative reform, the CEMNID Project has focused on NID only, per the definition in Section 3.1.1. Restoration, rehabilitation and offsetting have been more pervasive in conversations surrounding environmental impacts associated with projects.

Over the course of the Project, it became apparent that there were a number of limitations and data gaps on the topic of NID. For example, there are no known publicly available reports about the performance of the identified NID options in offshore wind farms in Scotland. Generally, there is little commercial scale evidence in support of NID options, and limited evidence in Scotland altogether. While some of these measures have been deployed and monitored elsewhere, this has frequently been in shallower coastal waters (see NID Literature Review for details). Consequently, there is considerable uncertainty with regards to the ecological success of these measures. This was highlighted within the NID Suitability Review which summarised the findings of the SWOT analysis; an absence of evidence in support of the effectiveness of NID options was consistently observed. As such, any recommendations made herein with regards to the deployment of NID should not be regarded as a guarantee of the success of these measures. In acknowledging this data gap, this also highlights the need for advancing knowledge on the performance of NID options in offshore wind farms in Scotland. The need to advance understanding about the ecological performance of NID measures in Scotland is one of the key findings of the Project and is discussed further in Section 4.

In addition to ecology, there are a number of technical considerations which are variable amongst NID options. Although several NID options are applicable across both fixed and floating technologies, structural soundness is of particular importance when looking at floating structures which exist in a high stress dynamic environment. This has financial and insurance consequences, with potential additional financial burdens for the developer. While NID measures do not intend to be financially or practically limiting, vessel and deployment costs can increase financial burden. Again, in the absence of commercial scale deployment of many of these measures, especially in the Scottish market, these financial and technical factors are hard to define with any great certainty.

3.3 NID Literature Review

The focus of the NID Literature Review was the identification of ecologically promising, practically applicable, and relevant NID options for offshore wind development in Scotland. Habitat-forming species ('ecosystem engineers') and policy-important habitats and species present in Scotland (e.g. Priority Marine Features) formed the focus of the research. This was done to provide a more targeted approach in the discussion on NID and its application for ecological benefit in Scotland. However, as noted in Section 3.2, it is important to acknowledge the limited data availability which prevents decisive conclusions on ecological benefits from being drawn. Detailed information on the identification and selection of habitat-forming and policy-important ecological features is provided in the NID Literature Review along with a complete list of these features.

The structure and function of identified NID options, the potential ecological services they may offer to features (e.g., attachment surface), the geographic distribution of ScotWind sites as well as key aspects on the biology and ecology of policy-important and habitat-forming species, contribute to the identification of a number of NID options which may potentially benefit 14 habitat-forming species and 15 policy-important habitats and species in Scotland (e.g.

Priority Marine Features). Detailed information on the identified NID options and ecological features is provided inthe NID Literature Review. However, it is important to clarify that the identification of ecologically relevant NID options for offshore wind farms in Scotland does not guarantee their ecological success. Limited, or absent, ecological benefits is a key risk that has been identified in previous reports regarding NID options in offshore wind farms (e.g. Hermans *et al.*, 2020; MRAG, 2023).

Publicly available literature documenting available NID measures (e.g. Didderen *et al.*, 2019; Hermans *et al.*, 2020; The Nature Conservancy and INSPIRE Environmental, 2021; MRAG, 2023 and references therein) focused on benthic habitats and species associated with hard substrates while soft sediments and species such as pelagic fish, marine mammals and seabirds were not considered. This is due to a lack of available information on how these receptors could directly benefit from the identified NID options. Given the limited information about how these features can benefit from NID options, these receptors were not considered further.

From the available literature, a number of NID measures were identified. These were subsequently grouped into five categories taking into account the structure and function of each NID option. The five categories are the following ones:

- Fish hotels/cage-type structures;
- Adapted rock protection measures;
- Reef-type structures and concrete blocks;
- Mattresses; and
- Water replenishment holes.

While a NID option may directly benefit a single habitat or species, some effects will be indirect, particularly at higher trophic levels. It is, however, important to note that the connectivity in food webs arising as a result of NID options is hard to define with certainty. In the absence of concrete evidence, the categories above allow for focus on those habitats/species which are likely to directly, or most obviously, benefit from the NID option.

3.4 SWOT Analysis and NID Suitability Review

A Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis was undertaken to provide a discursive, qualitative overview of the benefits and detractors associated with each of the five NID categories described above.

The SWOT analysis was populated taking into account ecological and technical expertise (consenting, commercial) within Xodus as well as information collected during the NID Literature Review. Ecological aspects took into account parameters such as habitat presence and spatial applicability. Technical aspects considered parameters such as practicalities in deployment, applicability of NID to floating versus fixed offshore wind structures, and any other important technical risks that may need to be considered from a practical, safety and legal perspective.

Once provisionally populated, the SWOT matrix was shared with stakeholders via a number of organised stakeholder workshops. Representatives from the following organisations were in attendance: Crown Estate Scotland, MD-LOT, NatureScot, Joint Nature Conservation Committee, Scottish Fishermen's Federation, Scottish White Fish Producers Association, and CEMNID Project Steering Group Developer Representatives. Stakeholder input was considered and formulated the basis for further consideration of NID suitability in Scotland.

For full details on the SWOT analysis including input from participants in the stakeholder engagement workshop, please see NID Suitability Review (A100906-S00-A-REPT-005).

3.4.1 Environmental Considerations

For each of the five NID categories, key information has been collected serving the assessment of their ecological and regional (in terms of ScotWind Plan Option Areas) relevance for offshore wind farms in Scotland. Key high level ecological principles that were examined included the geographic and bathymetric distribution of target habitats and species, key ecological aspects for each habitat and species (e.g. habitat requirements, feeding habits, spawning habitat). In addition, the structure (e.g. three-dimensional complexity) of NID options was examined in terms of the ecological services that they could provide to policy important habitat and species (e.g. habitat supply for PMF invertebrates). The examination of the parameters above enabled the ecological relevance assessment of the identified NID options for offshore wind farms in Scotland, with a focus on ScotWind Plan Option Areas.

Detailed information about the ecological relevance of each of the identified NID categories can be found in the NID Literature Review (A100906-S00-A-REPT-003) and the NID Suitability Review (A100906-S00-A-REPT-005).

3.4.2 Technical Considerations

For each of the five NID categories information has also been collected about technical considerations. Firstly, information is provided about the role that each NID option can have in an offshore wind farm development i.e., add-on units, scour protection, cable protection or stand-alone units. Each NID option was assessed for its suitability for fixed and/or floating infrastructure.

Combining a literature review, Xodus in-house engineering and environmental expertise and stakeholder engagement a series of technical considerations have been identified e.g. infrastructure stability challenges (e.g. use of 'add-on fish cages on floating infrastructure), method of deployment, transportation (e.g. towing for maintenance purposes), vessel time, vessel specifications and parameters shaping these requirements (e.g. number, size of NID options to be deployed as well as on the water depth that deployment will take place). Legislative framework (e.g. obligations to remove NID infrastructure at the end of project) and interactions of NID with sea users (e.g. snagging risk for fishing vessels) need also to be taken into account.

Xodus in-house expertise and stakeholder engagement also identified a number of financial parameters to be taken into account. For example, there are insurance risks associated with use of add-on measures necessitating alterations to structural design. Additionally, there may be implications on insurance cover with regards to replacement or maintenance works, or in terms of risks associated with NID use as an alternative to traditional rock scour protection measures.

Detailed information about the technical considerations associated with each of the five NID groups can be found in NID Literature Review (A100906-S00-A-REPT-003) and NID Suitability Review (A100906-S00-A-REPT-005).

3.4.3 Conclusions

Below there is a summary of the key outcomes of the SWOT analysis as well as a presentation of the key commonalities across all five NID categories (Table 6). The main characteristics of each of the four factors (strengths weaknesses, opportunities, threats) as well as the detailed outcomes of the SWOT analysis can be seen in the NID Suitability Review (A100906-S00-A-REPT-005).

- Environmental considerations: Based on the information analysed and presented in the NID Suitability Review it seems that all five NID categories may have potential ecological benefits across all the ScotWind Plan Option areas. The main drivers behind these are the following: a) most of the policy-important habitats and species have relatively wide geographic distribution across Scottish waters; b) most of the NID categories have high spatial applicability; c) most of the NID categories may provide more than one service (e.g. attachment surface, shelter, feeding ground etc) thus widening the number of ecological features that may benefit.
- Technical considerations: Many key considerations are applicable across both fixed and floating technologies (e.g. the technical view that welds are structural weak points and must be accessible for inspection). However, structural soundness is of particular importance when looking at floating structures which exist in a high stress dynamic environment. This has financial and insurance consequences, with potential additional financial burdens for the developer. While NID measures do not intend to be financially or practically limiting, there may be specific vessel requirement associated with the deployment of different NID options. Another key risk to NID deployment is potential for interaction with other users of the sea (e.g. snagging risk).

Table 6 Key common strengths, weaknesses, opportunities, and threats across all five NID categories

STRENGTHS
Can increase habitat complexity and thus support biodiversity enhancement – to an extent, this applies across all NID measures.
NID measures requiring installation of hard substrate or rock (adapted rock protection; modified mattresses) could supplement or act as introduced stony reef habitat. This could support a variety of species and habitats identified as being of conservation value in Scottish waters, and could have bottom-up consequences from low tropic levels up to highly-protected marine predators such as mammals and birds.
Demersal fish species may benefit through the provision of feeding grounds and shelter (fish hotels; adapted rock protection; reef structures-concrete blocks; modified mattresses; water replenishment holes).
Many of the NID measures have high spatial applicability – range can extend from the offshore wind array area all the way to nearshore (along the cable route), therefore benefitting a wide range of fauna and flora across a variety of water depths.
OPPORTUNITIES
Can be added onto existing structure (fish hotels; adapted rock protection; water replenishment holes).
Potentially applicable to both fixed and floating wind structures (fish hotels; adapted rock protection, reef structures-concrete blocks; modified mattresses).
WEAKNESSES
No long-term monitoring to determine the actual effectiveness of the NID measure *in situ* (knowledge gaps and unknown). This applies to most available NID options.
The location/area-specific environmental conditions need to be examined when considering the effectiveness of the NID options and interactions with other sea users. This applies to most available NID options.
Unlikely to be suitable in areas with protected soft sediment habitats (adapted rock protection; reef structures-concrete blocks; modified mattresses).

THREATS
It is likely that ecological benefits will disappear after the asset is decommissioned. This applies to most available NID options, with the potential exception of the adapted rock protection measures due to technical challenges.
Degradation of NID options over time and release of potentially harmful material in the environment (fibres, plastic, other contaminants) (e.g. adapted rock protection filter bags; reef structures-concrete blocks; modified mattresses).
Potential to contribution to the spread of invasive and non-native species (INNS) and diseases. This applies to most available NID options.
Spatial exclusion for fishing and other activities; snagging hazards in arrays where fishing might be possible (fish hotels; adapted rock protection; reef structures-concrete blocks; modified mattresses).
Financial risks associated with the implementation of insurance cover. This applies to most available NID options.

3.5 Process for Consideration of NID

The following process has been devised, as starting point, to help guide further project level consideration of NID options. The process highlights a number of key principles which must be considered when determining which NID are most suitable for a project (Figure 3). These principles are:

- Design type;
- Technical considerations;
- Environmental considerations; and
- NID options selection.

Any decision to include or discount potential NID options from the design envelope of a project should take account of principles above and be supported by related evidence where available.

There are some key points which must be considered under each of these broad principles. These are addressed in Section 3.5.1 below.

Section 3.5.2 presents a discussion surrounding the consideration of NID throughout a project lifecycle. This is shown in the context of an indicative project timeline.

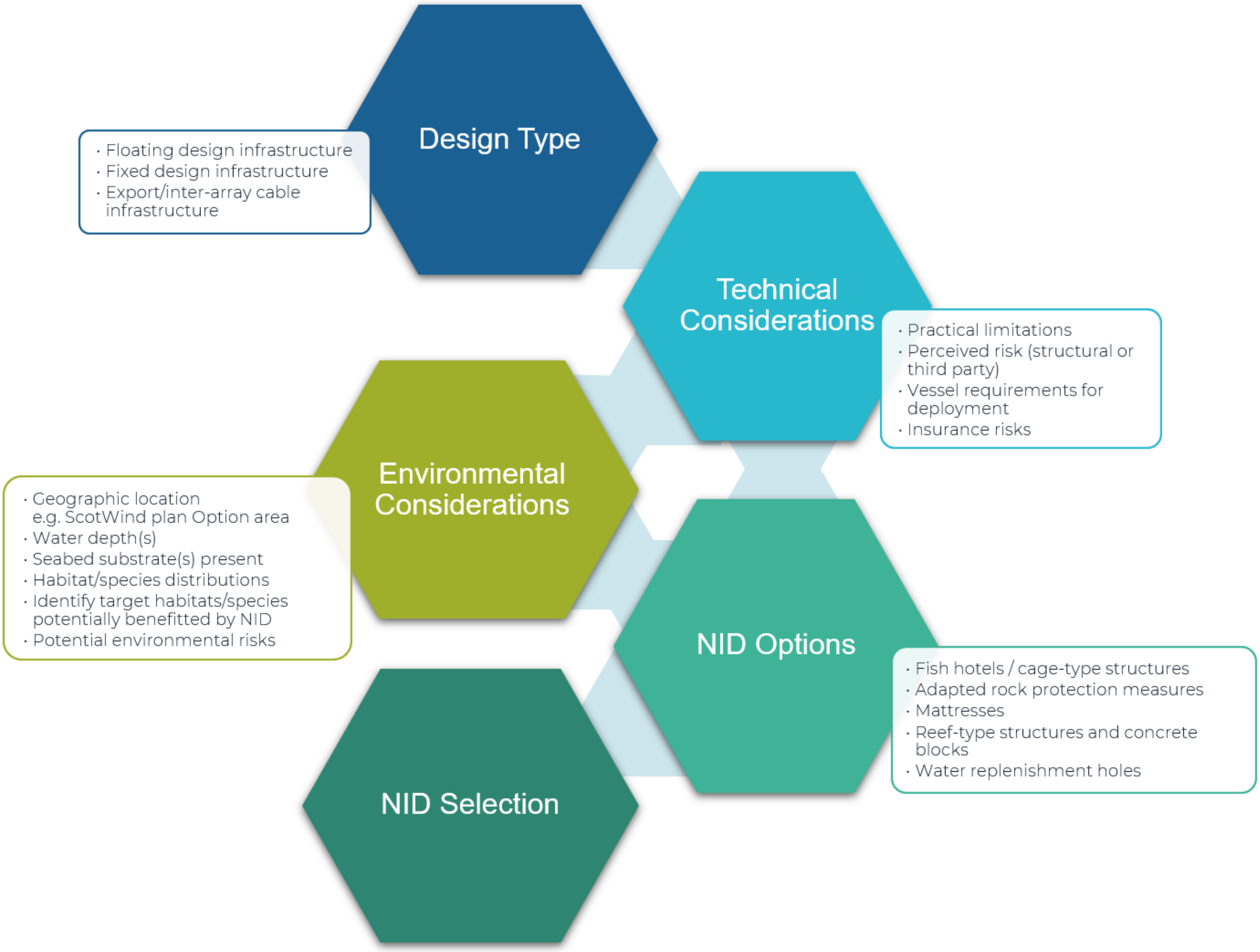

Figure 3 Indicative process for incorporation of NID in a Scottish offshore wind project

3.5.1 Consideration Process

Design type: The project design type is instrumental in informing the most appropriate type of NID. As described in Section 3.4 above, some NID groups are more or less suited to different types of infrastructure. A number of NID groups can be applied across both floating and fixed foundation offshore wind structures. Some NID groups are additionally suited for use alongside, or incorporation within, cable protection. Therefore, they can be applied along inter-array cables and along export cables. Therefore, consideration of design type will dictate the suitability of certain NID measures.

Environmental considerations: It is important to note that the process in Figure 3 is not linear – both environmental and technical aspects of NID deployment should be taken into account during the process. It is tentatively suggested that environmental consideration of policy-important habitats and species is done first. However environmental and technical principles are intrinsically linked – consideration of environmental conditions will influence technical factors, such as vessel requirements or insurance risks. Similarly, these technical factors may be limiting themselves and may rule out an NID measures on the basis of developer appetite for insurance risk. Examples of NID where this could apply may be add-on structures to floating wind designs which may add logistical issues with transportation and add more complexity (increased weld points, more drag) to the structure. However, ultimately it is assumed that the examination of technical considerations ahead of environmental ones will not lead to a different list of suitable NID options.

This category includes a range of parameters that will play a key role in decision making for the suitability of NID options. The ScotWind Plan Option areas cover a range of locations across the Scottish UK Continental Shelf (UKCS). Each of these areas have variable physical properties, such as metocean conditions, which warrant consideration. For example, more extreme metocean conditions and increased exposure may introduce additional stress on infrastructure and any add-on NID measures.

Other environmental parameters will vary with location, such as water depth (e.g. inshore, offshore areas) and type of substrate (e.g. rocky substrates, soft sediments, mixed etc.). Water depth relates to the consideration of the type of infrastructure – deeper waters necessitate floating WTGs. Therefore, some NID measures may be less applicable. Water depth is also a factor which limits species distributions. Some NID groups are better suited to targeting benthic species (e.g. reef-type structures and concrete blocks) versus others which may benefit pelagic fish species (e.g. fish hotels/cage-type structures).

As identified in Section 3.4, most of the NID groups would likely be of greatest benefit for hard substrate habitats (e.g. reef-type structures and concrete blocks) and the species these habitats support. Consequently, it is worth considering the nature of the seabed when determining which NID options are best suited; deposition of adapted rock protection NID options in soft sediments will lead to permanent changes to the pre-existing habitat which may not be the most appropriate measure to implement in the name of biodiversity enhancement.

Species distributions vary geographically in line with differing environmental conditions. The CEMNID Project has identified a list of policy-important habitats and species in Scottish water (see NID Suitability Review (A100906-S00-A-REPT-005)) which can help in the identification of the NID approach at a project level. The NID Suitability Review (A100906-S00-A-REPT-005) provides information on which NID options may benefit some example policy-important habitats and species. This offers interested parties an indicative thought process by which to narrow down the list of NID options that could be used across ScotWind.

Lastly, the Project has identified, as part of the SWOT analysis, some potential environmental risks that may hinder the success or suitability of NID options. For example, modified mattresses may not be able to withstand particularly strong currents. Similarly, it has been noted that plastic components within some NID measures may contribute to pollution as degradation occurs, particularly in measures such as alternative mattresses which may be designed to be decommissioned *in situ*. However, there is likely a degree of flexibility in defining the materials within some of these NID options – a number are noted as being customisable (see NID Literature Review (A100906-S00-A-REPT-003)). NID infrastructure may additionally facilitate the spread of invasive and non-native species through enhancing artificial substrates. The potential for entrapment of marine fauna in some NID measures is also a potential environmental risk – this is discussed further within the NID Suitability Review (A100906-S00-A-REPT-005)

> Overall, it is key to note the importance of site-specific information in supporting a robust decision-making process with regards to incorporation of NID in a project. Many of the environmental considerations discussed above are highly variable and will be location dependent. Therefore, a more comprehensive understanding of a location, as is supported by site-specific surveys for example, can be used to refine the opportunity for NID and better understand which species / habitats are most likely to benefit.

Technical considerations: Installation, transportation, and lifting activities of the NID options pose a series of technical considerations. For example, external add-on structures such as fish cages run the risk of being damaged themselves or damaging the wind turbine, particularly in transport. Damage during transport and installation activities is more likely to be associated with add-ons attached to fixed structures. However, this could be mitigated against by incorporation of NID after installation. Installation of NID could take place using divers or remotely operated vehicles. In any case, the installation of NID should consider any associated risks and challenges.

Fish cages have the potential of serving as an add-on option on floating offshore wind infrastructure; the dynamic nature of the environment, however, presents a significant challenge as it introduces a higher stress on the infrastructure and this needs to be factored in during the design. Increasing the mass added on floating designs (e.g. through a fish cage) may increase failure risk which, in turn, has insurance implications. During the operational phase, floating structures may have to be towed for maintenance purposes. Moving these structures may necessitate pre-cleaning or could lead to any accumulated biological growth falling off in transport.

The method of NID deployment and associated vessel time are also important parameters to be considered. For example, the deployment method for adapted rock protection may have to be modified to account for alternative rock grades which are substituted in order provide a greater complexity of rocky habitat. In terms of vessel time, there may be a slight increase associated with the deployment of adapted rock protection measures. Vessel specifications for the deployment of concrete blocks/reef-type structures may differ to typical construction vessels; this will depend on the number and size of reef-type/concrete block designs, as well as the target deployment water depth. While NID manufacturers do not intend for vessel requirements to be a prohibitive factor in installation of NID, this will remain a relatively unknown factor until NID measures are used more regularly in the industry.

Another important technical consideration is the recoverability of concrete blocks and reef-type structures. These NID options are not generally designed to be removed so if extensive re-deployment of reef blocks is required, this could come at considerable cost. The durability of materials may differ; for example, where traditional rock protection typically comprises granite, or another highly inert strong erosion-resistant rock, concrete may not have the same tried and tested durability, particularly when manufactured into a unique/alternative shape.

Interactions of NID options with other sea users is a major parameter that needs to be considered, especially with regards to the commercial fishing industry. Most of the NID options (with the exception of water replenishment holes) pose a snagging risk for bottom trawling gear. Implications on other sea users' interests should be considered, although the incorporation of NID measures in these areas will not necessarily have additional impact on fisheries in those cases where infrastructure (e.g. cable protection material) is already present. Where add-on options such as fish cages are incorporated into existing infrastructure, they will have an inherently lower snagging risk as they will be within the safety zone of the offshore wind infrastructure.

The information presented herein can support developers and stakeholders in the selection of promising NID options across ScotWind Plan Option Areas. It is important to note that there is limited information on commercial scale use of NID globally and none in Scotland, to date. Therefore, the success of any NID options cannot be guaranteed.

The limited available information highlights the need for advancing knowledge about the performance of NID options in offshore wind farms in Scotland, which needs the deployment, testing and monitoring of NID measures. Advancing knowledge about the ecological performance of NID measures in Scottish offshore windfarms, as well as the parameters that drive ecological success will also be important in advancing knowledge about the scalability of NID measures across Scottish offshore wind farms.

3.5.2 Timeline for Consideration of NID

The high-level schedule in Figure 4 highlights where in a project timeline NID might be considered. NID should be considered throughout the lifecycle of a project, inclusive of early concept design during pre-consent, all the way through to the operational phase. Consideration for including an NID option should take place as early as possible in a project lifetime. Any commitments to include NID in offshore wind project should take into account all relevant aspects e.g., technical feasibility as this may have implications on the timeline of a project. Consideration should also be given to the fact that at the moment the evidence about the ecological performance of NID options for offshore wind farms is limited.

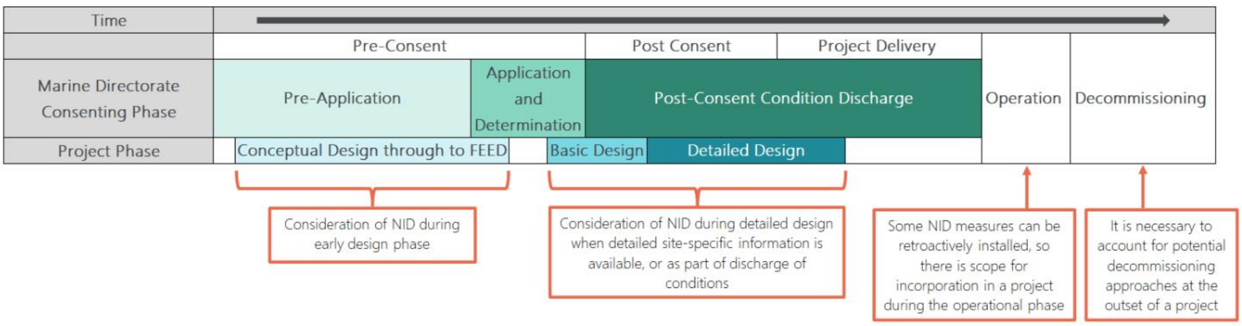

Figure 4 Indicative timeline for consideration of NID in a Scottish offshore wind project

From project inception, consideration should be made with regards to developer appetite for risk and trialling of relatively commercially untested technologies. Some of the NID measures, for example the add-on fish cages can be incorporated into the design of the WTG structures. This necessitates timely consideration of NID during the project early concept phase. This would also require agreement with the manufacturer such that structure specifications can accommodate the role of NID (i.e. additional weight).

At this time, incorporation of NID in a PDE would ensure that consent is achieved alongside overall project consent. Therefore, this minimises the need for additional subsequent permissions to be sought specifically for NID.

Prior to submission of a project application to MD-LOT, site-specific information allows for the refinement of the PDE and supports a more comprehensive understanding of the potential environmental impacts from the project. As described in Section 3.4, site-specific information is important in refinement of a project and in better anticipating which NID measures are best placed to support biodiversity in a given location. Therefore, potential NID options could be considered within the PDE when site-specific information is available.

The post-consent phase, as further detailed design is undertaken, presents an opportunity for incorporation of NID. However, this introduces potential Marine Licensing challenges for some NID options (e.g. reef-type structures and concrete blocks) if they are not considered part of a PDE from the outset. Should a decision be reached on NID during this time, beyond the scope of the original consented PDE, the NID may have to be covered by a separate Marine Licence, as appropriate. Deposits on the seabed require a Marine Licence which would be applicable to a number of the NID groups. Beyond this, add-on measures, such as cages, would likely not require a Marine Licence where they are located within the water column attached to existing structures.

It should be clarified that it is not the remit of the CEMNID Project to make recommendations about whether NID should or should not be included as part of the EIA process. Instead, the above discussion aims to point to where in a project lifecycle NID could be considered, if the intention is to apply it within a project. The findings of the CEMNID project could serve as a starting point for interested parties (e.g., offshore wind farm developers) in identifying and selecting NID options for offshore wind farms in Scotland to support nature-positive development in the marine environment.

As discussed in Section 3.5.1, some NID measures can be incorporated into the design of infrastructure from the outset. However, there is potential for the incorporation of NID during the operational phase of a development too. For example, while fish hotels/cage-type structures are generally incorporated into the design of a foundation, they can be attached externally retroactively once the foundation itself has been installed. This mitigates against the damages that may be incurred otherwise to add-on measures which protrude during transport and installation of foundations.

At the end of the operational life, when the time to decommission a project arrives, the process for decommissioning of NID options should have already been considered. Where some of the other NID groups may need to be removed at the time of decommissioning, rock placement is currently typically decommissioned *in situ* owing to technical difficulties associated with its removal. Consequently, NID measures such as adapted rock protection are unlikely to be recoverable. The long-term maintenance/management of NID options decommissioned *in situ* should be discussed and agreed between Offshore Transmission Owner (OFTO) and developer/windfarm operator.

The extent of NID environmental benefits will likely be limited to the duration of the presence of NID options in the marine environment; currently there is limited evidence about the interactions of NID options with ecosystem components and thus the extent of ecological benefits is uncertain. The SWOT analysis (see Section 3.4.3 and the NID Suitability Review (A100906-S00-A-REPT-005)) has highlighted concerns about the loss of any potential ecological benefits (e.g., organisms grown on hard substrate habitats) following the removal of NID options at the end of the project. Whether an NID option should be removed or decommissioned *in situ* will be examined on a case-by-case basis considering policy/legislative framework, and best available technical and scientific evidence.

The decommissioning strategy would be outlined differently according to the approach by which NID was consented. Where the NID was captured within a PDE from the outset, an approach to decommissioning would need to be included with the project's Decommissioning Plan (provision of which is a requirement at the time of seeking consent). Alternatively, where a separate Marine Licence has been obtained for NID, this would follow a separate process wherein a Decommissioning Plan would be submitted four months prior to proposed decommissioning.

Under OSPAR Decision 98/3, leaving disused offshore installations within the OSPAR maritime area is prohibited (with few exceptions).[3] It is, at this time, unprecedented for the ecological benefits of structures remaining *in situ* to be used as justification for this decommissioning approach. Furthermore, OSPAR Decision 98/3 was originally intended for the oil and gas industry, so its role in the renewables industry as a whole is quite unclear. In following the 1989 International Maritime Organisation standards (IMO, 1989), it can be assumed that all Decommissioning Programmes for renewable energy installations must start from a presumption of total removal. Where total removal would create unacceptable risks to personnel, or to the marine environment, be technically unfeasible or involve extreme costs, it is understood that exemptions may be considered. Consequently, there is a degree of uncertainty at present as to how a leave *in situ* case may be justified generally, and the reception of this approach. This uncertainly is inclusive of NID options and primarily applies to NID measures which are installed on the seabed.

In situations where structures may be permitted to be decommissioned *in situ*, the legal liability of the developer in the long term would have to be considered in advance. Structures remaining on the seabed represent a potential long-term risk to other sea users. The liability associated with this, and the impact of this on potential future leasing of the seabed, would need to be accounted for and understood from the outset.

Overall, the implications of decommissioning NID should be considered in the first steps of a project design and decision-making process, taking into account the policy and legislation framework and the best available technical and scientific evidence.

> Overall, NID could be considered at any stage of a project's lifecycle. NID can be incorporated into the early design of a project or can be retroactively installed during the operational phase of a project. However, these will necessitate different consent/licensing approaches. The consequences of decommissioning on NID should be considered in the early stages of a project.

[3] *OSPAR Decision 98/3 https://www.ospar.org/documents?d=32703*

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 CEMNID Project Objectives

The CEMNID Project was developed in order to contribute to filling in two key knowledge gaps as identified by the Scottish Offshore Wind Energy Council's (SOWEC) Barriers to Deployment – Enabling Group.). These gaps were as follows:

- Identification of the most appropriate mitigation measures for species receptors that can be applied to offshore wind developments in Scotland when applying the mitigation hierarchy; and,
- Opportunities to apply NID to Scottish offshore wind projects in order to contribute to biodiversity enhancement and nature positive outcomes from such developments.

Broadly, these two points focus on mitigation measures and NID separately, but both have distinct roles within the mitigation hierarchy (as defined in Section 2.1.1 and 3.1.1, respectively). In order to address these knowledge gaps, the CEMNID Project proposed five main objectives. The overarching objectives of the CEMNID Project were to:

1. Provide a clearer understanding of how to apply the mitigation hierarchy in offshore wind development, including consideration of embedded measures and design decisions (Section 4.1.1);
2. Summarise good practice environmental mitigation measures available to deploy through the mitigation hierarchy (Section 4.1.2);
3. Identify the principles of NID for offshore wind development, including how these relate to the mitigation hierarchy (Section 4.1.3);
4. Identify ecologically promising and practically applicable NID measures that could be applied to Scottish offshore wind projects (Section 4.1.4); and,
5. Provide evidence to support the consenting requirement to implement nature-positive development in the marine environment and thereby comply with adopted National Planning Framework 4 (NPF4) and emerging policies within the National Marine Plan 2 (NMP2) (Section 4.1.5).

Discussion is provided in the sections below on each of these objectives in turn. Lastly, some recommendations are proposed based on the outcomes of the CEMNID Project in Section 4.2, including how to apply the Good Practice Library and how to consider implementation of NID in Scotland.

4.1.1 Objective 1

Provide a clearer understanding of how to apply the mitigation hierarchy in offshore wind development, including consideration of embedded measures and design decisions.

The Project considered the role of standard practice mitigation measures in the offshore wind industry, and their position within the mitigation hierarchy. The scope of the Project considered avoidance and minimisation-type mitigation measures, based on the first two levels of the mitigation hierarchy. Some primary and tertiary mitigation measures are principally implemented, or embedded, as a consequence of engineering/design requirements, but also happen to have environmental benefits and therefore are included within Project scope. While these benefits may be consequential, they can represent good practice from an environmental perspective and thus inclusion in the Good Practice Library can help these are carried into project decision making. In addition, the Good Practice Library takes into account the three tiers of mitigation (primary, secondary, and tertiary) and the project stages at which these apply are considered.

The work undertaken by the CEMNID Project has highlighted across the board the need for consideration of the mitigation hierarchy at each stage in a project's lifecycle. From the project early concept stage, avoidance and minimisation measures should be considered when planning a project. Beyond this, throughout the consenting process, consideration of mitigation measures is required as the PDE is refined. In addition, stakeholder engagement has highlighted the evolution of mitigation measures between pre- and post-consent, suggesting that continuous review of mitigation measures is necessary.

4.1.2 Objective 2

Summarise good practice environmental mitigation measures available to deploy through the mitigation hierarchy.

The work described in Section 2 on Good Practice Mitigation Measures, aimed to identify which mitigation measures are commonly utilised and accepted in offshore wind across Scotland (and the wider UK), and further extrapolate which of these could be considered good practice (as defined in Section 2.1). To achieve this, a Good Practice Library was created following a literature review of mitigation measures based on pre- and post-consent project documentation, guidelines and scientific papers. The process for generation of the Good Practice Library is described in Section 2.6. The Good Practice Library aims to inform those in the industry as to the range of good practice mitigation measures which can be deployed in offshore wind.

In addition to the Good Practice Library, the work undertaken as part of the CEMNID Project expanded on this further by examining a subset of measures and bringing together the publicly available information in support of describing mitigation measure efficacy (see the Mitigation Measures Efficacy Review). This subset of measures were broadly grouped into four themes: underwater sound, avian collision risk, avian disturbance and displacement, and EMF. These themes relate primarily to the following receptors: marine mammals, ornithology, benthic ecology, and fish and shellfish.

While being mindful of its limitations (Section 2.2), the findings of the Project suggest that, on the whole, mitigation measures are generally effective in achieving their intended purpose. However, this does not preclude the need for secondary mitigation measures as well as further innovation.

4.1.3 Objective 3

Identify the principles of NID for offshore wind development, including how these relate to the mitigation hierarchy.

The work undertaken on the CEMNID Project has highlighted the need for consideration of NID at each stage in a project's lifecycle – from initial concept through to operational phase and decommissioning. The project timeline and proposed NID decision making process (in Section 3.5.1) aims to highlight the need for consideration of NID at each project stage, through to decommissioning.

The CEMNID Project has identified a series of parameters/principles that should be taken into account when NID is considered for offshore wind developments in Scotland. The identification of these parameters was facilitated through NID Litarature Review, stakeholder engagement, SWOT analysis, and collaboration with the Rich North Sea programme on SWOT analysis and NID suitability. The key parameters that warrant consideration when looking to implement NID are design type, technical considerations, environmental considerations, and lastly the range of available NID options.

The CEMNID Project has identified a list of potentially ecologically relevant and technically feasible NID options for offshore wind developments in Scotland, which are discussed further within Section 4.1.4 below. In addition, as part of the NID Suitability Review, CEMNID has provided useful information that can guide the identification of promising NID options across ScotWind lease areas. It should be mentioned that the available information about the ecological performance of NID options on a global scale is (very) limited while in Scotland this type of information is rather absent. NID can be used to complement other measures instated through the mitigation hierarchy to reach nature positive outcomes.

A key Project recommendation is that of the development of pilot projects in Scotland which utilise NID. Monitoring of the ecological performance of NID options in Scottish waters is key to understanding the role that NID can fulfil in Scotland. This is important in advancing the potential for achievement of net positive outcomes in Scottish offshore wind.

4.1.4 Objective 4

Identify ecologically promising and practically applicable NID measures that could be applied to Scottish offshore wind projects.

While a number of NID measures were identified withinthe NID Literature Review , these have broadly been categorised within five groups based on similarities in the NID intended objectives, and/or technical specifications/physical structure. These five groups are as follows:

- Fish hotels/cage-type structures;
- Adapted rock protection measures;
- Reef-type structures and concrete blocks;
- Mattresses; and
- Water replenishment holes.

A SWOT analysis was undertaken to define the benefits and detractors associated with each group. Stakeholder engagement was conducted such that representatives from a wide range of backgrounds could provide feedback on the SWOT analysis and highlight any additional points for consideration.

One of the key limitations identified over the course of the Project, and in the SWOT analysis, is the absence of Scottish data in support of NID use. While there is some evidence more broadly which shows some NID measures to be effective, there are few examples of NID used at a commercial scale, particularly in the offshore wind industry. Therefore, a key Project recommendation suggests that NID measures should be trialled in pilot schemes in Scotland (Section 4.2) so that ecological benefits can be better understood. These trials should be targeted such that there are very clear aims for investigation. This positive feedback loop can be used to reinforce inclusion of NID at a project level and will contribute to the wider basis of understanding on NID effectiveness.

The NID Suitability Review considered the applicability of the five NID groups in a Scottish context. In the absence of evidence at the time of writing, some inferences have been made with regards to the suitability of NID measures in Scottish offshore wind. Ultimately, the Project has determined that, at this point in time, there are no NID groups which can be immediately discounted or should be preferentially used in Scotland. Consequently, all five groups are considered potentially ecologically promising and practically applicable to Scotland.

Each of the five NID groups have differing technical specifications which can be variably applied to fixed, floating, and cable infrastructure; therefore, applicability will be based on individual project level specifications. What is common across all NID groups is that their greatest ecological benefit will be felt most directly by benthic species and fish receptors. The importance of site-specific conditions is key to informing the use of NID in Scottish projects. Additionally, developer appetite for risk will likely contribute to the process by which NID are incorporated in projects.

The process in Section 3.5, aims to provide the industry with a systematic method by which NID can be considered at a project specific level. This process aims to highlight the above points, and more, such that an informed decision can be reached by developers.

4.1.5 Objective 5

Provide evidence to support the consenting requirement to implement nature-positive development in the marine environment and thereby comply with adopted National Planning Framework 4 (NPF4) and emerging policies within the National Marine Plan 2 (NMP2).

The CEMNID Project aimed to provide evidence in support of potential inclusion of nature positive measures in policy frameworks. However, a key finding of the Project has been the limited evidence base, particular for NID given its relative absence in commercial scale wind projects, especially in Scotland. While desk-based evidence is valuable, real observational data is lacking and therefore a definitive conclusion in favour of inclusion of NID at a policy level cannot yet be determined. Instead, the findings of the Project can act as a starting point for interested parties (e.g. offshore wind farm developers) in identifying and selecting NID options for offshore wind farms in Scotland to support nature-positive development in the marine environment. Despite the limited evidence, there is considerable opportunity for growth in this area with regards to incorporation of NID at a plan or policy level. At most, the current state of knowledge would lean toward encouraging developers to first consider NID options and how these may provide positive outcomes on a case by case basis (Section 3.5).

Scotland's draft biodiversity strategy sets out our clear ambition for Scotland to be Nature Positive by 2030, and to have restored and regenerated biodiversity across the country by 2045 (Scottish Government, 2022). This strategy has fed into NPF4 which applies to the intertidal, onshore and offshore elements of offshore wind projects. Some offshore wind developers have responded to meeting the requirements of NPF4 policies 1, 2 and 3 which have a focus on creating more sustainable places, whether this is through mitigation and adaptation to the climate crisis or biodiversity enhancement (e.g. West of Orkney Wind Farm Outline Biodiversity Enhancement Plan submitted in 2024). Similarly, the ongoing update to the National Marine Plan (NMP) may involve translation of NPF4 policies 1, 2, and 3 into a marine context for NMP2 to ensure both plans are in sync. NID could have a place within these policies within the context of applying the mitigation hierarchy, a focal point within the NMP. NMP2 is due to be in place in 2025 and will apply to all marine sectors.

At a more strategic level and in response to global biodiversity frameworks, tender and investor requirements, developers have been responding and reporting at a corporate level on the need to address net-positive biodiversity impacts. For example, Ørsted's ambition is that all new renewable energy commissioned from 2030 onwards should deliver a net-positive biodiversity impact (Ørsted, 2024) and bp's ambition is to have plans in place for all projects (in scope) to achieve net positive biodiversity impact, with a target for 90% of actions to be delivered within five years of project approval (bp, 2024). These plans could drive investment in nature positive solutions for projects, including NID. The CEMNID Project aims to facilitate this ongoing progress and provide useful guidance to developers undertaking additional processes beyond those outlined in policy at present.

4.2 Recommendations

Over the duration of the Project, some clear avenues for further work became apparent. In acknowledgement of the limitations and uncertainties that were identified over the course of the CEMNID Project, a number of recommendations are made here:

1. The Good Practice Library can be used as a resource to inform selection of mitigation measures.

The Good Practice Library can be a valuable resource, which has been designed to be easy and practical to use. However, it is important to acknowledge its limitations and caveats, namely that it is not exhaustive and that not all measures may apply across all projects and as such secondary mitigation options are under-represented as these are driven by individual project specific assessments. The limitations of the CEMNID Project with regards to work undertaken on mitigation measures are described in Sections 2.2 and 2.6.

It is also important to acknowledge that the Library represents the current status of mitigation measures in the industry in Scotland and the UK. As technologies mature and emerge, and as policy landscapes change, the Library may become outdated. Therefore, a degree of caution is recommended when using the Library to ensure that the information is being applied appropriately. Ultimately, the continued maintenance of the Good Practice Library is recommended.

2. Targeted and proportionate monitoring efforts should continue to be undertaken, and the outputs should be shared across the industry.

It is important to acknowledge that monitoring efforts are currently underway, but the relatively young age of the offshore wind industry in Scotland (and the fact that many consented wind farms in Scotland are not yet fully operational) means that these outputs have yet to represent longer term data sets. This long-term monitoring is required to build further confidence that deployed mitigation measures are as reliable and effective as expected. It is also important to note that post-consent monitoring targets receptors, not mitigation measures themselves thus it should be acknowledged that the efficacy of mitigation deployed is not necessarily confirmed by monitoring data which is more generally acquired to corroborate findings of the EIA. Given that there is no clear metric by which mitigation measure efficacy can be measured, extrapolation and assumptions largely underpin any conclusions that can be drawn on mitigation measure success. It should also be considered that ongoing monitoring can enable the possibility of adaptive mitigation if required and potentially also to support further considerations for NID measures during the operational phase of the project life cycle.

With regards to availability of these outputs, the centralisation of the data gathered through monitoring efforts presents an opportunity for improved knowledge sharing across industry. The Offshore Wind Evidence and Knowledge Hub (OWEKH) is an example of such a knowledge sharing platform, along with the RAGs across Scotland. Knowledge sharing is strongly recommended as an important part of the monitoring process as the learnings from developers can influence the thinking in the wider industry going forward and access to this information will help developers of new projects make the most informed decisions based on the most up to date available data (e.g., for guidance and role of regulators and SNCBs see Scottish Government 2018;NatureScot 'Advice on marine renewables development[4]).

3. The Project would encourage pilots and trials for emerging and promising mitigation measures and NID in Scotland.

Further trials and pilots are recommended in order to demonstrate mitigation measure efficacy as well as suitability of NID.

In the case of mitigation measures, it is proposed that these can be particularly useful for emerging mitigation technologies such as those relating to underwater noise and collision risk and displacement of seabirds such as lighting studies and the painting of turbines where there are currently data deficiencies. The results from such studies can help to grow the body of evidence for their consideration in mitigation plans for commercial scale projects.

Targeted NID trials at a project level, can reinforce further internal project decisions with regards to the implementation of NID. Useful information about the design of pilots and trials can be extracted from various sources e.g., considering the outputs of the INSITE Research Programme in the North Sea[5] and startups' innovations supporting biodiversity in the offshore wind sector (SeaAhead, 2024). Advancing knowledge about the potential ecological benefits of NID will also be helpful in improving understanding about the scalability of NID in the offshore wind sector in Scotland. Additionally, decommissioning is one of the suggested key areas which would warrant further investigation and targeted trialling. As it stands, NID is yet to be commercially deployed in offshore wind in Scotland. Therefore, it may be some time before the implications of decommissioning are understood. Consequently, when trials are conducted, this should be a principal area of focus.

4. Collaboration across stakeholder groups is advantageous and should be encouraged.

Stakeholder engagement undertaken over the course of the Project highlighted the benefits of early and ongoing engagement over the duration of the project. Transparency among developers, regulators and other stakeholders can contribute to a willingness for innovation and in doing so can further the use of NID in industry. Early and continuous engagement also aims to reduce consenting risk.

[4] *https://www.nature.scot/professional-advice/planning-and-development/planning-and-development-advice/renewable-energy/marine-renewables/advice-marine-renewables-development*
[5] *https://insitenorthsea.org/*

Developers in industry, regulators, SNCBs, and other interested parties have the capacity to collaboratively develop and implement trials and monitoring practices.

5. The process for incorporating mitigation measures and NID in an individual project is not linear and should be considered at every step of a project lifecycle.

As outlined in Section 2.1.1, primary and tertiary mitigation measures are generally incorporated early in the project design phases. However, it is important that mitigations should also be kept in mind throughout the project lifecycle. For example, these include development of appropriate INNS mitigations that are drawn up following consent of a project (as part of an INNS management plan) or secondary mitigations that are considered throughout the determination process. Post-consent monitoring may also inform the requirement for adaptive mitigations that may not have otherwise been anticipated.

Section 3.5.1 aims to provide a basis for consideration of NID in Scottish offshore wind at the project level, at every step of a project lifecycle. The process documented therein can be followed such that relevant factors contributing to use of NID are fully considered on a project-by-project basis. In Section 3.5.2, this is put into the context of a project timeline.

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