Crown Estate Scotland

Collaboration for Environmental Mitigation & Nature Inclusive Design (CEMNID)

NID Literature Review

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CONTENTS

EXECUTIVE SUMMARY

The role of the Collaboration for Environmental Mitigation & Nature Inclusive Design (CEMNID) Project is to address environmental uncertainty for the offshore wind sector in Scotland through two key aims:

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

The aim of this NID literature review is to identify the range of potentially ecologically suitable NID options for offshore wind farms in Scotland.

With the ecological appropriateness of NID being the focus of this literature review, the first step in the process was determining a series of ecological criteria against which the NID options could be considered – these criteria best describe the mechanism by which the NID option may benefit the environment (e.g., through provision of attachment surfaces or serving as a spawning ground). The development of the ecological criteria was followed from the review of publicly available documents for NID options for offshore wind farms. This review was not limited to Scotland, literature from all available geographic locations was considered.

In addition, lists of habitats and species were compiled in order to identify those that may benefit from the identified NID options. Aiming to maximise the potential benefits of the identified NID options, the review focused on habitat-forming and policy important species for Scotland (e.g., Priority Marine Features, habitats/species listed in the OSPAR List of Threatened and/or Declining Species and Habitats, Annex I habitats). Information on the spatial and bathymetric distribution of offshore wind farms in Scotland, was compared against the distribution of habitat-forming and policy important habitats/species in Scottish waters. Habitat/species ecology (e.g., nursery, feeding, spawning) and the pathways through which they could potentially benefit from the identified NID options (e.g., becoming attached to the surface of an NID option) were also considered. In the case that an identified NID option could potentially benefit at least one habitat or species in Scottish waters (through the criteria mentioned above), it was characterised as an ecologically relevant NID option for offshore wind farms in Scotland.

The literature review has identified a number of NID options that are potentially ecologically relevant for offshore wind farms in Scotland. The identified NID options were almost exclusively associated with hard substrates (e.g., concrete mattresses, reef cubes). The NID options were grouped in five categories considering their structure and function. The categories are as follows:

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

The review process determined that the identified NID options may benefit 14 habitat-forming species and 15 policy-important species in Scotland. The identified NID options may benefit habitats and species through various ways, e.g., acting as attachment surfaces for sessile invertebrates, feeding and spawning ground for fish and skates, nursery grounds for fish, shelter for lobsters.

The identified NID options and the acquired ecological information will be used in the upcoming CEMNID deliverables; in particular, this information will be used during the Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of NID options and in the subsequent NID Suitability Review (A-100906-S00-A-REPT-004) which aims to provide information to stakeholders on the suitability of NID options to offshore wind projects in Scotland.

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 receptors that can be applied to offshore wind developments in Scotland when applying mitigation hierarchy; and
- Identify opportunities to apply 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 on 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[1] 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 adopted National Planning Framework 4 and emerging policies including National Marine Plan 2 (NMP2).

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 Outputs of the CEMNID Project

The CEMNID Project aims to achieve the objectives outlined above through provision of the following key deliverables:

- 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 (current deliverable, 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 (A100906-S00-A-REPT-007):
  - Structured report including discussion of mitigation good practice and guidance on implementing NID at a project level.

[1] *Good practice defined in this context as "Good practice is defined as a process or methodology that has been consistently shown to work well and to achieve reliable results" (IEEM, 2021).*

1.3 Aim of the deliverable

The current deliverable has carried out a systematic literature review of international evidence of NID approaches for offshore wind developments. The identified NID options have focused on habitat-forming and policy important species in Scottish waters that may benefit from the identified NID options. The identified NID options and ecological information gathered as part of the literature review will contribute to subsequent deliverables and assist in identification of ecologically promising, practically applicable, and relevant NID options for offshore wind development in Scotland.

1.4 Definition and aims of NID

The mitigation hierarchy is a key guiding principle for any project to address potential adverse impacts. Using definitions adopted by the Biodiversity Consultancy (2024), the first step of the mitigation hierarchy comprises measures taken to avoid creating impacts from the outset. Beyond this, minimisation aims to reduce the duration, intensity and/or extent of impacts that cannot be completely avoided. Effective minimisation can eliminate some negative impacts. After minimisation comes restoration, and lastly offsetting completes the mitigation hierarchy. Where restoration aims to improve degraded or removed ecosystems following exposure to impacts that cannot be completely avoided / minimised, offsetting aims to compensate for any residual, adverse impacts. Offsets typically constitute restoration and rehabilitation efforts.

The CEMNID Project defines NID measures as those which are integrated into the design of an offshore structure with the aim of supporting specific species or species groups, or which seek to enhance species richness. Ultimately, NID aims to support biodiversity enhancement and nature positive outcomes. This is generally in agreement with definitions found across the wider literature e.g., NID is regarded as integrated measures which aim to increase suitable habitat for native species and enhance ecological functioning (Hermans *et al.*, 2020; The Nature Conservancy and Inspire Environmental, 2021; Nordic Energy Research, 2023). In the context of the mitigation hierarchy, NID falls broadly within the concept of restoration where the aim is to improve degraded or removed ecosystems following exposure to impacts.

Avoidance and minimisation mitigation measures are the focus of the CEMNID Project deliverable Mitigation Measures Literature Review (A-100906-S00-A-REPT-002). While the mitigation hierarchy does include habitat rehabilitation and offsets, the CEMNID Project has opted not to incorporate restoration/enhancement options. Work on restoration and enhancement has gathered pace recently, from individual projects to potential indicators of policy and legislative reform. Due to these factors and uncertainties across the board, the CEMNID Project will focus on avoidance and minimisation mitigation measures and NID. In the context of the mitigation hierarchy NID broadly falls between minimisation and restoration (Figure 1).

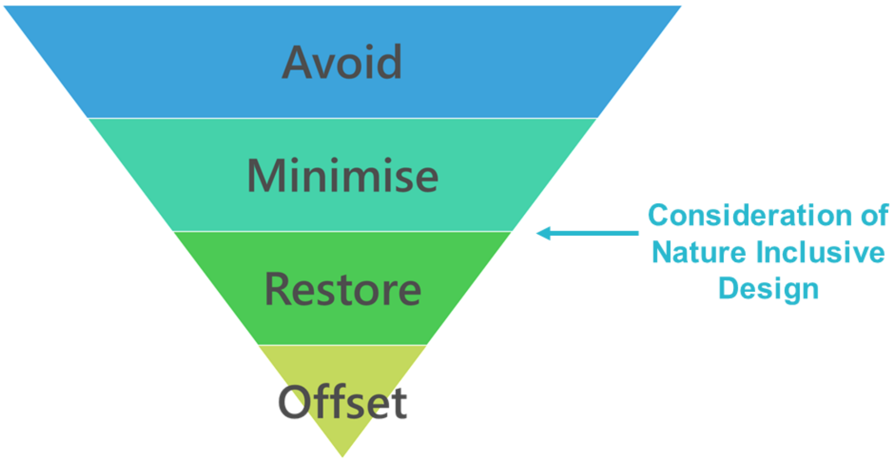


Figure 1 Consideration of Nature Inclusive Design in the Mitigation Hierarchy

This literature review has found that the focus so far in this field has been on NID options that are associated with hard substrates supporting the enhancement of benthic/benthopelagic species and communities (e.g., Bureau Waardenburg, 2020; Hermans *et al*., 2020; The Nature Conservancy and Inspire Environmental, 2021; MRAG, 2023). Therefore, the NID options outlined herein largely cater towards hard substrate habitats and associated species. Therefore, only policy-important habitats / species and habitat forming species characteristic of harder substrates have been considered herein (further detail provided in Section 2.1 and Section 2.4).

Some scour-protection measures that reduce sediment transport, thereby support softer sediment communities, have been identified (e.g., SSCS polypropylene frond mattresses – https://sscsystems.com/scour). However, such measures were not included in the wider NID literature because they are better described as mitigating against scour impacts, as opposed to increasing the presence of or enhancing soft sediment habitats (i.e. the literature review did not include scour-protection measures that were not perceived as NID specific for species and habitats associated with hard substrates). Consequently, they are not considered to fit the above definition of NID. Furthermore, they ultimately contribute to plastic pollution in the marine environment through their degradation over time. Considering these limitations, these frond mattresses were not considered further in this literature review.

More widely, practices that are mainly associated with mitigation of impacts and not biodiversity enhancement and nature positive outcomes (e.g., mitigation of possible lighting impacts from offshore wind farms) were not considered either.

2 METHODOLOGY

The main aim of this literature review was to utilise available information and literature to identify ecologically relevant NID options for offshore windfarms in Scotland. The steps that were followed and the criteria that were used for the identification of ecologically relevant NID options in offshore wind farms in Scotland are the following:

2.1 Criteria for ecologically relevant NID options

Having examined the available literature for NID options (e.g., Hermans *et al.*, 2020; MRAG, 2023), five criteria were created for the identification of ecologically relevant NID options. The criteria were:

- Supply of attachment surfaces;
- Supply of shelter;
- Supply of feeding ground;
- Supply of spawning ground;
- Supply of nursery ground.

The above criteria were chosen in order to capture the range of potential ecological benefits which an NID option may facilitate throughout the trophic levels. While an 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 the habitats/species which are likely to benefit the most from NID options.

Where an NID option was considered to fulfil at least one of these criteria for at least one habitat-forming or policy-important habitat / species in Scottish waters, then this NID option was considered as ecologically relevant for offshore wind farms in Scotland. This was based on expert knowledge and understanding of the habitat or species. This understanding was cognisant of the aforementioned limitations and uncertainties. Habitat-forming species are those which collectively build habitats and can alter local environmental conditions and, in doing so, promote biodiversity (e.g., reef-building polychaete species like the Ross worm, *Sabellaria spinulosa*). Policy-relevant habitats and species are defined as those which are included in a policy framework, namely one or more of the following frameworks:

- Scottish Priority Marine Features (PMF);
- Scottish Biodiversity List (SBL);
- UK Biodiversity Action Plan (BAP);
- Wildlife and Countryside Act 1981;
- Great British Red List (GB Red List);
- OSPAR Threatened and / or Declining (T&D) Habitats and Species;
- The European Commission Habitats Directive;
- IUCN Red List;
- Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS);
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES);
- Bern Convention; and

- Bonn Convention.

2.2 Interventions through which NID can be delivered

The literature review has revealed that the above criteria can be met through a series of design interventions on artificial habitats such as the creation of crevices, holes, grooves, ridges etc. For example, provision of surfaces for attachment can be achieved through the creation of textured surfaces and increases in surface area, and feeding grounds can be created through provision of grooves which host prey species (e.g., small sized invertebrates preyed by benthopelagic predator fish).

Below are brief descriptions about habitat types that can be created or may benefit through interventions in artificial substrates, and how this may benefit supported and associated species. The following information is synthesised from Conservation Evidence (2024), and references therein:

- Textured surfaces. Texture is micro-scale roughness applied to an entire surface that produces depressions and / or elevations ≤1 mm (Strain *et al.*, 2018). The texture can shape settlement and survival providing anchor points for larvae and algal germlings protecting them from dislodgement and predation (Carl *et al.*, 2012) There is some evidence supporting that rougher texture facilitates colonisation by invertebrates and algae (Miller and Barimo, 2001; Sempere-Valverde *et al.*, 2018) promoting community development. Textured surfaces can be seen in scour protection (reef cells, truncated cuboctahedrons, frond mattresses), cable protection (frond mattresses) and standalone units (reef ball and layer cakes, reef cubes).
- Crevice habitats. Crevice habitats are depressions with a length to width ratio >3:1 and depth >50 mm. They can provide organisms refuge from desiccation and temperature fluctuations (e.g., in intertidal rocky habitats) and refuge from predation. Size and density of crevices can affect the type, size and number of organisms found in them. These microhabitats can be seen in scour protection (e.g., rock layer, basalt bags) and cable protection materials (e.g., additional rock layer, reef cube mats).
- Groove habitats. Groove habitats are depressions with a length to width ratio >3:1 and depth 1-50 mm. They can provide organisms refuge from desiccation and temperature fluctuations as well as shelter from predation or grazing. The size and density of grooves can affect the size, abundance and variety of organisms that can use them. Grooves can be seen in scour protection and cable protection materials (e.g., additional rock layer, mattress blocks, concrete scour protection units).
- Hole habitats. Hole habitats are depressions with a length to width ratio ≤3:1 and depth >50 mm. Hole habitats provide organisms refuge from desiccation and temperature fluctuations during low tide in intertidal rocky habitats (Williams and Morrit, 1995). They also provide shelter from predation or grazing (Menge and Lubchenco, 1981). The density and size of holes is likely to affect the size, abundance and variety of organisms that can use them. Hole habitats can be seen in scour protection (e.g., reef cubes, fish hotels).
- Adjoining cavities or 'swimthrough' habitats. The size of 'swimthrough' habitats can be either relatively small (<100 mm) or large (>100 mm). It is likely that in the intertidal zone organisms in cavities/swimthrough habitats can refuge from desiccation, temperature fluctuations and predation, in a similar way to crevices, grooves and hole habitats (Menge and Lubchenco 1981; Williams and Morritt, 1995). As with other types of habitats (e.g., crevices, grooves) the size and density of cavities can affect the type, size and abundance of organisms that can use them. Swimthrough habitats can be found in add on options (e.g., biohut, cod hotel), scour protection material (e.g., reef cubes) and standalone NID options (e.g., steel pipes, fish hotel, oyster gabions).

- Protrusions. The size of protrusions varies. Small protrusions are elevations with a length to width ratio ≤3:1 that protrude 1-50 mm from the substratum. They can provide organisms protection from desiccation and temperature fluctuations during low tide in the intertidal zone (Williams and Morrit, 1995) and also shelter from predation or grazing (Wahl and Hoppe, 2002). Some organisms preferentially recruit to habitats with high vertical or horizontal relief (Harmelin-Vivien *et al.*, 1995). Large protrusions are elevations with a length to width ratio ≤3:1 that protrude >50 mm from the substratum. Large protrusions can protect species from their predators (Meese and Lowe, 2020) and have positive effects on fish populations (Morris *et al.*, 2018). Some species preferentially recruit to habitats with high vertical or horizontal relief (Andrews and Anderson, 2004). As with other types of habitats mentioned above, the size and density of protrusions is likely to affect the size, abundance and variety of organisms that can use them. Protrusions of various sizes can be found in scour protection material (e.g., additional rock later, reef cells, scour protection units) and cable protection material (e.g., concrete mats).
- Ridges and ledges. The size of ridges and ledges varies. Small ridges and ledges are elevations with a length to width ratio >3:1 that protrude 1–50 mm from the substratum while the large ones protrude >50 mm from the substratum. On vertical surfaces vertically-orientated elevations are referred to as 'ridges', while the horizontal ones are ledges. On horizontal surfaces, these features are referred to as 'ridges' regardless of their orientation. Regardless of size ridges and ledges can protect organisms from their predators (Wahl and Hoppe, 2002) and enhance fish populations (Morris *et al.*, 2018); some species preferentially recruit to habitats with high vertical or horizontal relief (Andrews and Anderson, 2004). The size and density of ridges and ledges is likely to affect the size, abundance and variety of organisms that can use them. Ridges and ledges can be found in scour protection (truncated scour protection units, frond mattresses), cable protection (e.g., frond mattresses) and standalone units (e.g., reef ball and layer cakes, 3D printed units).

Based on the available literature (Hermans *et al.*, 2020; MRAG, 2023), NID options have also been categorised according to how each intervention may be integrated into offshore wind farms infrastructure. These concept categories are:

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

The full list of NID options is shown in Section 3.1 (Table 1).

2.3 Literature review for the identification of NID options

This literature review has examined publicly available documents for offshore wind developments UK and elsewhere (e.g., The Netherlands, USA) in order to compile a list of potential NID options (Didderen *et al.*, 2019; Hermans *et al.*, 2020; The Nature Conservancy and INSPIRE Environmental, 2021; MRAG, 2023 and references therein). The search for the identification of reports on NID options for offshore windfarms did not set a specific time period within which the reports should have been published. A key commonality across the reviewed literature is that the NID options identified are made of hard substrates (e.g., steel pipes, concrete reef cubes). Therefore, they are most likely to benefit hard substrate habitats and associated species. Species / habitats associated with soft sediments were not generally considered in the literature. A similar approach has been followed here.

In addition, publicly available literature focused on benthic species and habitats (e.g., sessile invertebrates, demersal fish) while species such as pelagic fish (not directly associated with benthic environment), 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 pelagic fish (other than benthic spawners), marine mammals and seabirds can benefit from NID options for offshore wind farms in Scotland, these receptors were not considered in this literature review.

The wider literature categorised NID options within the four following groups: add on options; scour protection options; cable protection options; and standalone options. This categorisation approach has also been followed here, in parallel to the categorisation of NID options as

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

The categories of the NID options can be seen in Table 1.

2.4 Review of species and habitats in Scottish waters that could benefit from NID options in offshore wind farms

As described in Section 1.4 and Section 2.3, the species and habitats review focused on benthic and benthopelagic ecosystem components associated with hard substrates as currently there is limited information about the potential benefits for receptors like marine mammals and seabirds (Didderen *et al.*, 2019; Hermans *et al.*, 2020; MRAG, 2023).

Furthermore, as it was described in Section 2.1 the review focused on habitat-forming species and policy-important habitats and species (e.g., Priority Marine Features, OSPAR Threatened and/or Declining Habitats and Species, Annex I habitats), aiming to maximise the potential benefits of NID options. Habitats and species in Scottish waters that are not habitat-forming or covered by policy were not considered further.

In addition, considering that the average water depth of an offshore wind farm in Scotland (inclusive of fixed and floating) does not exceed 200 m, habitat-forming species and policy-important habitats/species that are found mainly at water depths exceeding 150-200 m were not considered. This is due to their limited potential for benefit from NID options.

Finally, aiming to identify those habitat-forming species and policy-important species that have the potential to benefit from NID options associated with offshore wind farms in Scotland, we considered the spatial distribution of offshore wind farms in Scottish waters, inclusive of ScotWind areas. The spatial distribution of offshore wind farms in Scotland was examine through the NMPi data layer entitled "Offshore wind lease sites – Crown Estate Scotland" (https://marinescotland.atkinsgeospatial.com/nmpi/). Potential spatial overlap between offshore wind lease sites, export cable routeing and the distribution of habitat-forming species and policy-important habitats and species was also investigated. The spatial distribution of habitat-forming species and policy-important habitats and species in

Scotland was investigated through the relevant NMPi GIS data layers (e.g., the layers for PMF species). In those cases where there was no overlap between the offshore wind lease sites, export cable routeing and the spatial distribution of the policy important habitats and species these features were not considered further. For example, serpulid worm aggregations have only been recorded infrequently in lochs on the west coast of Scotland. Thus, an overlap between wind lease sites and these habitats is highly unlikely. It is important to note here that most of the offshore wind lease sites are found in the north or along the east coast of Scotland. However, there is an offshore wind lease site in western Scotland found at the southern part of the Inner Hebrides. Due to the presence of this wind lease site in west coast we have also considered habitat-forming and policy-important species that are found on the west coast (e.g., spiny lobsters) where an overlap between these wind lease sites and these habitats (e.g., through a cable corridor) is possible.

Based on the above considerations, habitats and species in Scotland which may benefit from the identified NID options are presented in Section 3.3, along with the ecological justification for their inclusion. The habitats and species that were not considered further in this literature review are shown in Appendix A.

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. The ecological performance of the identified NID options has not yet been tested in practice in Scotland. Ecological failure is one of the major risks that have been identified in previous reports regarding NID options in offshore wind farms (e.g., Hermans *et al.*, 2020; MRAG, 2023). Where international evidence exists in support of NID options, this has been presented in Section 3.2.

The list of identified NID options in Section 3.1 (Table 1) should be used by stakeholders as a starting point in consideration of NID options in Scottish offshore wind.

3 RESULTS

3.1 NID options that potentially are ecologically relevant for offshore wind farms in Scotland

Using the ecological criteria described in Section 2.1 and the available reports for NID options in offshore wind farms, we have produced the list below showing NID options which are potentially ecologically relevant for offshore wind farms in Scotland (Table 1). Each NID option has been grouped under a NID concept i.e., add on, scour protection, cable protection and standalone units which are installed as part of project infrastructure. Grouping NID options using this concept has been followed in previous reports regarding NID options in offshore wind farms (Hermans *et al.*, 2020; The Nature Conservancy and Inspire Environmental, 2021; MRAG, 2023). A number of the measures are relatively similar structurally and in terms of the function they provide, however the suppliers differ. These similar NID options have been grouped for ease in the table on the assumption that approximate costs and installation methods will be relatively analogous across the options within each group. The groups are as follows:

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

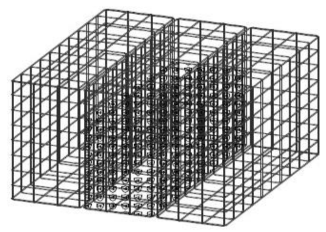
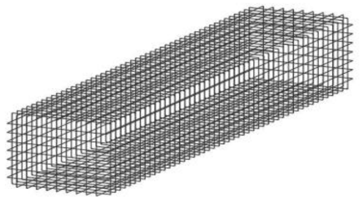
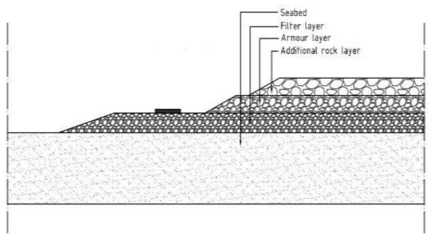
For each of the identified NID options we provide a summary of information on technical specifications of the NID option (e.g., size), further details of the option, examples of policy-important habitats and species in Scotland that may benefit from the identified NID option, and information on the designers and/or suppliers of the NID option. In addition, a judgement has been made as to which aspect of offshore wind infrastructure each NID option may be associated. For example, some NID options are exclusively associated with fixed foundation technologies, versus others which are also applicable to floating technologies or those which are alternatives to cable and scour protection measures.

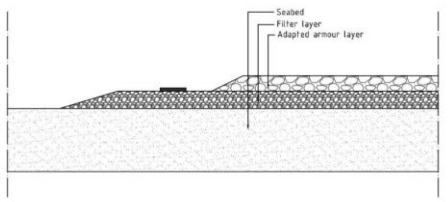
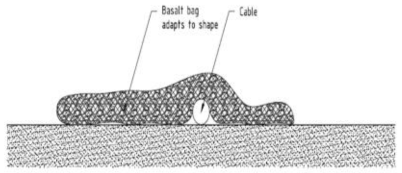
At the time of writing, there are no known publicly available reports regarding the performance (e.g., utilisation from species in terms of habitat supply, feeding ground; enhancement of survival, reproductive success) of the identified NID options in offshore wind farms in Scotland. However, some of the identified NID options have been deployed and monitored elsewhere (e.g., reef cubes). Available ecological evidence which supports the narrative around NID option efficacy is presented in Section 3.2 (see Table 2). It should be mentioned that available ecological evidence about the performance of NID options is limited, especially long-term studies. It should be acknowledged that many of the NID options are relatively similar structurally and yet mention the possibility of benefit to different habitats or species. It is important to note that where examples of policy-important habitats and species which may benefit from each NID option are listed, this information has been obtained from other sources. Where there is relatively little differentiation between some of the NID options, in reality it is likely that there will be little to distinguish the benefit to other species. This information is presented by way of an example.

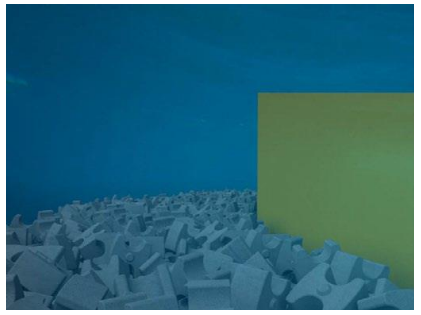
Considering that some NID options may have been tested elsewhere but not yet in Scotland, we have set the status for each NID options in Scotland as "ready to be tested". Finally, it should be mentioned that the information about the technical specifications of each NID option have mainly been extracted from Hermans *et al.* (2020), The Nature Conservancy and Inspire Environmental (2021), and MRAG (2023).

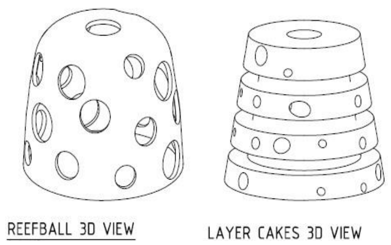
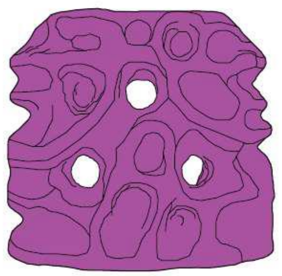
Table 1 Ecologically relevant NID options for offshore wind farms in Scotland

NID CONCEPT	NID OPTION	IMAGE	ASSOCIATED INFRASTRUCTURE	SPECIFICATIONS AND FURTHER INFORMATION	HABITATS AND SPECIES THAT MAY BENEFIT FROM NID OPTIONS	STATUS / DESIGN / SUPPLIERS
Fish hotels / cage-type structures						
Add on unit / Standalone unit	Cod hotel / fish hotel		Fixed	There are three main parts to the cod hotel: the saddle which connects the frame to the jacket; the steel frame; and steel gabion basket interspersed with steel tubes and monitoring funnels (Hermans *et al.*, 2020). Suggested proportions for the cod hotel are 2 m high by 1 m wide and 1 m long (Hermans *et al.*, 2020). The suggested mesh size ranges from 5 cm x 5 cm to 10 cm x 10 cm. Perforated tubes of 1 to 2 m with varying diameters (e.g., from 13 cm to 25 cm) pass through the mesh. The perforations on the tubes are suggested to be larger than 7.5 cm but smaller than 15 cm. Modifications can be made to accommodate opportunities for eDNA sampling. The size can also be adjustable. A key risk associated with this measure is the potential for structural failure. This is due to the absence of evidence to define the environmental load which the structure can withstand. As an add on unit, this may have consequences on the integrity of the primary structure, i.e., the jacket foundation (Hermans *et al.*, 2020).	Atlantic cod (and other fish species) may benefit from the cod-hotel through the supply of shelter and feeding grounds. Assumptions of cod biomass production using the cod hotel can be found in Hermans *et al.* (2020). The hotel may also offer suitable settlement surface for many benthic species, as well as feeding opportunities.	Ready to be tested Design/Suppliers: EcOcean (utilised by TenneT; https://renewables-grid.eu/) Witteveen+Bosdesign (www.witteveenbos.com/)
Standalone unit	Habitat pipes	 Pipe 3D view	Fixed / Floating	These pipes are made of steel. One end of the pipe ends must always be accessible, and with at least four holes of at least 15 cm and at most 30 cm to guarantee through flow of water. To withstand hydraulic pressures, the arrangement of hydraulic pipes must be carefully considered. While these pipes are considered to be a more stable alternative to concrete pipes, steel corrosion (and subsequent potential for structural failure) are a potential risk.	Hermans *et al.* (2020) describe that the pipes facilitate the settlement of sessile species compared to other types of material (e.g., concrete). The surfaces of the pipes may serve as attachment surfaces for sessile organisms (e.g., sponges, feather stars). They may also serve as feeding ground for fish (e.g., Atlantic cod). The holes in the steel pipes allow species to move in and out of the pipes. In this way they may act as a shelter for fish (e.g., Atlantic cod). Notably, steel is not suitable for oyster settlement.	Ready to be tested Design/Suppliers: N/A
Standalone unit	Fish hotel (WUR)		Fixed / Floating	An alternative fish hotel is made of concrete tubes which can be interlocked and stacked. Suggested design: (Hermans *et al.*, 2020): Length: 80 cm Diameter: 36 cm Small hole diameter: 10-15 cm Minimum number of tubes for a Fish hotel per location: 5	The fish hotel aims, primarily, to increase the biomass of fish species. Hermans *et al.* (2020) mention that the fish hotel shelters relatively large Atlantic cod specimens, which ensures a higher reproductive rate. This is in comparison to the cod hotel described above which may serve to support smaller individuals / juveniles.	Ready to be tested Design/Suppliers: ReefSystems MOSES Block (https://www.reefsystems.org/moses) design by Wageningen University & Research (wur.nl)

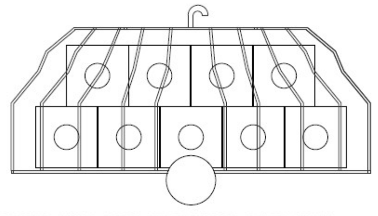
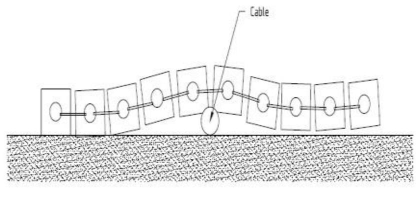
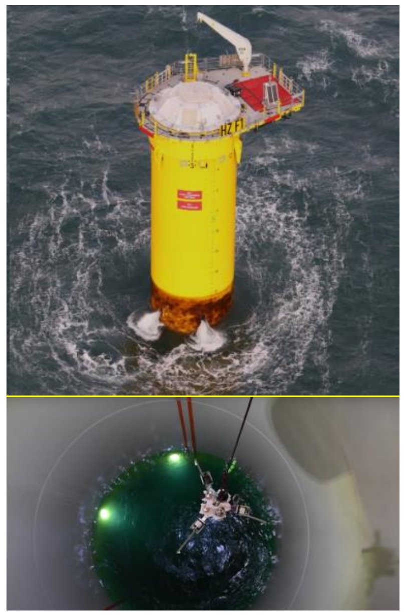
NID CONCEPT	NID OPTION	IMAGE	ASSOCIATED INFRASTRUCTURE	SPECIFICATIONS AND FURTHER INFORMATION	HABITATS AND SPECIES THAT MAY BENEFIT FROM NID OPTIONS	STATUS / DESIGN / SUPPLIERS
Add on unit / Standalone unit	Biohut®	 3D VIEW BIOHUT	Fixed / Floating	The Biohut® is made from 2-3 adjoining cages. The cages can be adjusted for installation on an asset/or as a standalone unit. As standalone cage structures, these could be placed in association with scour protection surrounding foundation structures. Initially designed for use in a coastal context, the Biohut® can be adapted for use in offshore wind farms (Hermans *et al.*, 2020). The suggested design describes a cage 2 m (height) x 1 m (width) x 1 m (length), with a mesh size of 10 cm x 10 cm. Funnel-shaped tubes (input funnel 30 cm, end funnel 10 cm) can be used to facilitate eDNA sampling (Hermans *et al.*, 2020).	Juvenile Atlantic cod and other fish species may benefit from the Biohut® through the supply of shelter. The cage structure can also offer some settlement opportunity for benthic species, creating a more complex habitat.	Ready to be tested Design/Suppliers: Patented Biohut® design by Ecocean (www.ecocean.fr)
Standalone unit / Add on unit	Oyster gabions	 3D VIEW OYSTER GABION BASKET	Fixed / Floating	This is a mesh net cage which can be installed directly on the armour layer of the scour protection. The size of the mesh should not be larger than 5 x 5 cm to prevent shell from falling out. Hermans *et al.* (2020) suggest that the mesh net cage can by filled with oyster shells, the function of the gabions being to create additional hard substrate suitable for oyster growth. The assumption is that both living and dead shells can be within the cage structure. Suggested design (Hermans *et al.*, 2020). Length: 200 cm Width: 150 cm Height: 40 cm	Oyster gabions increase the substrate area for European flat oysters' growth. In Hermans *et al.* (2020) it is mentioned that oyster gabions can also provide shelter for small Atlantic cod specimens.	Ready to be tested Design/Suppliers: unknown
Add on unit / Standalone unit	Oyster tables (or oyster broodstock structures)		Fixed / Floating	The oyster tables or oyster broodstock structures are designed to host adult oysters. Up to date three versions of this design have been used in pilot projects. The design includes a stable concrete base and different options for adding adult oysters: in cages or glued either on horizontal concrete slabs or vertical concrete poles. The tables are designed so they can be hoisted up for monitoring (Didderen *et al.*, 2019).	Oyster tables add adult oysters to the broodstock population of European flat oysters.	Ready to be tested Design/Suppliers: Van Oord/TU Delft
Adapted rock protection measures						
Optimised scour-protection layer	Additional rock layer	 ADDITIONAL ROCK LAYER	Fixed / Floating	This NID option considers the addition of a rock layer with adjusted grading placed on top of the standard protection layer. The specifications of adjusted grading are not explicitly defined. The additional layer contributes to the creation of crevices of various sizes (10 – 30 cm in diameter, 20 - 50 cm in depth) (Hermans *et al.*, 2020). This would have to be taken into account during scour or cable protection design in order to ensure consideration of implications on local commercial fishing activity.	The additional rock layer may also supply attachment surfaces for sessile invertebrates (e.g. sponges, feather stars). Juvenile cod and other fish species may benefit from the additional rock layer through the supply of shelter. According to Hermans *et al.* (2020) if the rock layer is seeded with European flat oyster (adults and / or spat on shell), it could be the starting point of an oyster reef.	Ready to be tested Design/Suppliers: Quarry suppliers

NID CONCEPT	NID OPTION	IMAGE	ASSOCIATED INFRASTRUCTURE	SPECIFICATIONS AND FURTHER INFORMATION	HABITATS AND SPECIES THAT MAY BENEFIT FROM NID OPTIONS	STATUS / DESIGN / SUPPLIERS
Optimised scour-protection layer	Adapted grading armour layer	 ADAPTED GRADING ARMOUR LAYER	Fixed / Floating	Optimised layer can replace the typical armour layer. Similar technical specifications apply as described under the NID option additional rock layer above (Hermans *et al.*, 2020). This would have to be taken into account during scour or cable protection design in order to ensure consideration of implications on local commercial fishing activity.	The additional rock layer may also supply attachment surfaces for sessile invertebrates (sponges, feather stars). Atlantic cod may benefit from the adapted grading armour layer through the supply of shelter. Biomass production estimates can be found in Hermans *et al.* (2020).	Ready to be tested Design/Suppliers: Quarry suppliers
Optimised cable protection layer / Optimised scour-protection layer	Filter Unit®		Fixed / Floating	The filter unit is a polyester mesh net filled with rocks. The filter unit can be used for the protection of cables. Hermans *et al.* (2020) suggest a grading of 40 - 200 kg in order to provide crevice sizes: 10 cm to 30 cm in diameter and 20 to 50 cm depth. Polyester will degrade over time in the marine environment. Therefore, intentions at the time of decommissioning would have to be considered in advance of installation.	The filter unit may serve as a feeding ground for fish (e.g., Atlantic cod) predating on invertebrates colonising this NID option. Considering that the filter unit can supply openings / sheltered areas it is assumed that it may also serve as nursery ground and shelter for fish (e.g., saithe, Atlantic cod) and shelter for European spiny lobsters.	Ready to be tested Design/Suppliers: Sumitomo Deutschland GmbH (sumitomo-filter-unit.com)
Optimised cable protection layer	Basalt bags	 FRONT VIEW BASALT BAG	Fixed / Floating	The basalt bags are mesh nets filled with rocks, slightly flexible in their structure. The basalt bags can be used for the protection of cables. The basalt bags are similar to filter units but the outer casing of the net/bag is comprised of basalt fibre, a type of fibre made from natural basalt rocks (MRAG, 2023).They contain quarry rock with a well sorted grading of 40-200 kg. The basalt bags will create crevices 10 cm to 30 cm in diameter and 20 to 50 cm depth (Hermans *et al.*, 2020). Basalt bags provide an alternative to polyester bags (described above).	The basalt bags facilitate the creation of openings / sheltered areas and they may serve as nursery grounds and shelter for fish (e.g., saithe, Atlantic cod) and for European spiny lobsters. Hermans *et al.* (2020) mention that the bags can be inhabited by other species creating an artificial reef.	Ready to be tested Design/Suppliers: JägerMare Solutions GmbH (jaeger-maresolutions.com)
Concrete blocks						
Optimised scour-protection layer	Repurposed concrete		Fixed / Floating	Concrete and steel are highly durable and stable materials. The repurposed concrete can be used for scour/cable protection. This material can increase habitat complexity through the creation of crevices, grooves, protrusions etc. (The Nature Conservancy and INSPIRE Environmental, 2021). The Nature Conservancy and INSPIRE Environmental (2021) report mentions that concrete or rock material that has already been submerged in a marine environment supports quicker colonisation of epifauna. In addition, the report mentions that concrete from bridges has shown a high success rate as an artificial reef material in marine and estuarine environments. However, a key risk here would be the introduction of invasive non-native species (INNS) which may outcompete local fauna.	Repurposed concrete may supply attachment surfaces for sessile organisms (e.g., sponges) and feeding grounds for fish (e.g., saithe).	Ready to be tested Design/Suppliers: Janus Materials (janusmaterials.com)

NID CONCEPT	NID OPTION	IMAGE	ASSOCIATED INFRASTRUCTURE	SPECIFICATIONS AND FURTHER INFORMATION	HABITATS AND SPECIES THAT MAY BENEFIT FROM NID OPTIONS	STATUS / DESIGN / SUPPLIERS
				Size: ranges from pea gravel or 57 stone (crushed stone aggregate) to large riprap (rock armour or rubble) and large structured pieces. Weight of a single unit: approx. 2.5 tonnes per cubic meter		
Optimised scour-protection layer	ECOncrete® Wind Turbine Scour Protection Unit		Fixed / Floating	These are interlocking, concrete units used in scour protection. They are intended to replace/complement rock armour scour protection in offshore wind turbines. The design of the units creates microhabitats such as crevices, holes and protrusions. Size of individual unit: Approx. 0.6 m (length) x 0.4 m (width) x 0.2 (height). Units can be combined to form an interlocking array. Weight of a single unit: approx. 50 kg.	The scour protection units may supply attachment surfaces for sessile organisms (e.g., sponges) and feeding grounds for fish (e.g., saithe).	Ready to be tested Design/Suppliers: ECOncrete® Inc (www.econcretetech.com)
Optimised scour-protection layer	ExoHedron for Offshore Wind Scour Protection		Fixed / Floating	The truncated cuboctahedron ExoReef can be used in scour protection. They incorporate flat surfaces, structures surfaces and swim through tunnels. The designers mention that the use of scalable ExoReef units increases marine biodiversity. This is supported through the facilitation of environmental variability and the creation of microhabitats.	The ExoHedron scour protection units may supply attachment surfaces for sessile organisms (e.g., sponges), feeding grounds and shelter for fish (e.g., saithe, Atlantic cod).	Ready to be tested Design/Suppliers: (www.exo-engineering.co.uk/)
Optimised scour-protection layer	ExoSphere Scour Protection		Fixed / Floating	ExoSpheres can be used in scour protection. They have a rather flat outer surface and host swimthrough habitats with a large centre cavity. The weight and size of ExoSpheres is customisable.	The ExoSphere scour protection units may supply attachment surfaces for sessile organisms (e.g., sponges), feeding grounds and shelter for fish (e.g., saithe, Atlantic cod).	Ready to be tested Design/Suppliers: (www.exo-engineering.co.uk/)
Optimised scour-protection layer	Frond ExoMatt Edge Weighting		Fixed / Floating	ExoMatt can be used in scour / cable protection. They have textured surfaces and swimthrough habitats. The designers mention that the completed ExoMatt represents an opportunity for replenishment of soft and hard sediment environments.	The Frond ExoMatt may supply attachment surfaces for sessile organisms (e.g., sponges), feeding grounds and shelter for fish (e.g., saithe, Atlantic cod). The designers also mention that the textured surface could encourage the settlement of native oysters.	Ready to be tested Design/Suppliers: (www.exo-engineering.co.uk/)

NID CONCEPT	NID OPTION	IMAGE	ASSOCIATED INFRASTRUCTURE	SPECIFICATIONS AND FURTHER INFORMATION	HABITATS AND SPECIES THAT MAY BENEFIT FROM NID OPTIONS	STATUS / DESIGN / SUPPLIERS
Standalone unit	Reef cube®		Fixed / Floating	The structure is made of concrete and can be used in scour protection. Units and can be placed one on top of the other. Sizes can vary depending on target species. As standalone units, these could be incorporated within or around areas of scour protection. Suggested (basic) design (Hermans *et al.*, 2020): 50 cm x 50 cm x 50 cm Hole diameter: 20 cm Number of holes per cube: 6	The reef cubes may act as an attachment surface for sessile organisms (e.g., sponges, *S. spinulosa*, feather stars). A large number (>200) of structures could be placed around a monopile to create a reef structure. They may also serve as feeding grounds for fish (e.g., Atlantic cod). Hermans *et al.* (2020) indicate that the material is designed to enhance the settlement of European flat oysters on the cubes.	Ready to be tested Design/Suppliers: Patented design by ARC Marine (arcmarine.co.uk)
Standalone unit	Reefball® and Layer cakes		Fixed / Floating	These units are made from reinforced concrete and can be used in scour protection. They host holes / swim through habitats and textured surfaces. As standalone units, these could be incorporated within or around areas of scour protection. Suggested design Hermans *et al.*, 2020): Height: 130 cm Base diameter: 189 cm Surface area 21 m^2	The layer cakes create horizontal surfaces which may facilitate the attachment of sessile organisms (e.g., sponges, feather stars); this shape is preferred from an ecological perspective. The surfaces and holes of the Reefball® may serve its use from fish (e.g., Atlantic cod) as shelter and feeding ground. Hermans *et al.* (2020) highlight that Reefballs® and layer cakes supply a relatively large surface area in a relatively compact space which ensures high food availability.	Ready to be tested Design/Suppliers: Patented design by ReefballFoundation® (reefball.org)
Standalone unit	3D printed reefs		Fixed / Floating	The reefs are made from 70% sand and 30% cement and can be used in scour protection. They resemble layer cakes consisting of several levels that are connected to each other by hollows. As standalone units, these could be incorporated within or around areas of scour protection. The structures are 1 m^3 in size with a height of 1 m.	The 3D printed reefs may supply attachment surface for sessile organisms (e.g., sponges, feather stars). The holes / swim through habitats of the reefs can serve as feeding ground and shelter for fish (e.g., Atlantic cod).	Ready to be tested Design/Suppliers: The 3D-printed reefs are designed and developed based on a collaboration between WWF Netherlands and Reef Design Lab. The reef structures are produced by the Italian company D-Shape (d-shape.com/)
Standalone unit	3D printed units		Fixed / Floating	These units are made of sand and can be used in scour protection. Since they are printed there is flexibility around the shapes that can be produced. As standalone units, these could be incorporated within or around areas of scour protection. Suggested design (Hermans *et al.*, 2020): Maximum base size: 1.5 m^2 Complex texture, randomly allocated holes fitting the size of target species.	The 3D printed units may act as an attachment surface for sessile organisms (e.g., sponges, feather stars). They may also serve as a feeding ground and shelter for fish.	Ready to be tested Design/Suppliers: unknown

NID CONCEPT	NID OPTION	IMAGE	ASSOCIATED INFRASTRUCTURE	SPECIFICATIONS AND FURTHER INFORMATION	HABITATS AND SPECIES THAT MAY BENEFIT FROM NID OPTIONS	STATUS / DESIGN / SUPPLIERS
Standalone unit	ECO armour block®		Fixed / Floating	The block is made of concrete and can be used in scour protection. The exact concrete mix purportedly has a reduced CO_2 footprint compared against traditional concrete. As standalone units, these could be incorporated within or around areas of scour protection. Suggested design (Hermans *et al.*, 2020). Height: 120 cm Width: 120 cm Depth: 120 cm	The armour block may supply attachment surfaces for sessile organisms (e.g., sponges, feather stars). In Hermans *et al.* (2020) it is mentioned that the concrete mixture is claimed to enhance settlement by sessile organisms. The armour block may also serve as a feeding ground for fish.	Ready to be tested Design/Suppliers: Patented design by ECOncreteTech (econcretetech.com)
Standalone unit	Reef Cell Modules		Fixed / Floating	The reef cells are made of concrete, and they are designed to mimic natural reefs. The module is characterised from the presence of holes, swimthrough habitats, chambers of various sizes and textured surface. As standalone units, these could be incorporated within or around areas of scour protection. Size of a single unit: approx. 1.5-2.4 m (height) x 2.1 m (width) Weight of a single unit: approx. 8.9 to 18.5 tonnes	The reef cell modules may serve as an attachment surface for sessile organisms (e.g., sponges, feather stars). Providing space to small-sized invertebrates (e.g., polychaetes, crustaceans) they may also serve as a feeding ground for fish (e.g., Atlantic cod) which predate on them. The smaller inner chambers may also provide shelter to fish.	Ready to be tested Design/Suppliers: Reef cells (reefcells.com).
Mattresses						
Optimised cable protection layer	Exomatt for floating offshore wind		Fixed / Floating	ExoMatt is placed on cables aiming to offer effective protection from scour. The designers mention that the textured surfaces of the units facilitate biocolonisation from sessile organisms. Clients are able to custom design micro- and macrofeatures which can target the requirements for specific species such as tunnels which help juvenile lobsters to avoid predation.	Exomatt may supply attachment surfaces for various sessile organisms (e.g., mussels, oysters, kelps, sponges). It also may serve as feeding ground for fish (e.g., Atlantic halibut), spawning ground for fish (e.g., Atlantic herring), feeding/spawning ground for skates and shelter for European lobsters.	Ready to be tested Design/Suppliers: (www.exo-engineering.co.uk/)
Optimised cable protection layer	ECO Mats®		Fixed / Floating	These mats are designed to provide flexible, stable protection for cables. They are composed of interlocking concrete blocks connected with a polyester cable (Hermans *et al.*, 2020). The design of the mats (interlocking units, texture surfaces) enhances habitat complexity (e.g., creation of crevices) and facilitate colonisation from sessile and mobile organisms. The designers mention that ECO Mat dimensions can be tailor-made. The dimensions of each concrete block are: 30 cm (length) x 24 cm (width) x 15 cm (height) The dimensions of the mat are: 570 cm (length) x 240 cm (width).	The mat has textured surfaces and can also contribute to the creation of crevices. The mattresses may supply attachment surfaces for various sessile organisms (e.g., mussels, oysters, kelps). It also may serve as feeding and spawning grounds for fish (e.g., Atlantic halibut, Atlantic herring), feeding / spawning grounds for skates and shelter for European spiny lobsters.	Ready to be tested Design/Suppliers: Patented design by ECOncreteTech (econcretetech.com)

NID CONCEPT	NID OPTION	IMAGE	ASSOCIATED INFRASTRUCTURE	SPECIFICATIONS AND FURTHER INFORMATION	HABITATS AND SPECIES THAT MAY BENEFIT FROM NID OPTIONS	STATUS / DESIGN / SUPPLIERS
				The concrete mix purportedly has a reduced CO_2 footprint compared against traditional concrete.		
Optimised cable protection layer	Reef cube bag™		Fixed / Floating	The reef cube bag can be used in the protection of cables. It is composed of reef cubes (see above the standalone unit "Reef Cube" for details) and is placed on top of cables. According to Hermans *et al.* (2020) the reef cube bag could provide a more homogeneous structure compared to the filter unit and the basalt bags. The material of the mesh bag and the size of mesh are unknown but may be adaptable.	The reef cube bag may supply attachment surfaces for various sessile organisms (e.g., mussels, oysters, kelps). The cube bag may also act as feeding ground, nursery ground and shelter for fish e.g., Atlantic cod. It may also serve as a spawning ground for skates.	Ready to be tested Design/Suppliers: Patented design by ARC Marine (arcmarine.co.uk)
Optimised cable protection layer	Reef cube matt™		Fixed / Floating	These are flexible mattresses and have reef cubes as their building units (see above, the standalone unit "Reef Cube" for details). These matts can be used in the protection of cables. The structure of the cube mattresses facilitates the creation of crevices and sheltered areas. The material associated with attaching the reef cubes together is unknown.	The mattress may act as an attachment surface for sessile organisms (e.g., native oysters, mussels, kelps). It may also act as feeding and spawning ground for fish (e.g., Atlantic halibut, Atlantic herring), nursery ground for fish (e.g., Atlantic cod), feeding / spawning grounds for skates and shelter for European spiny lobsters.	Ready to be tested Design/Suppliers: Patented design by ARC marine (arcmarine.co.uk)
Optimised cable protection layer	Fleximats®		Fixed / Floating	This cable protection mat has a high degree of flexibility, which enables it to follow the cable shape. The mat is built from concrete blocks and polypropylene rope. Each mattress is approximately 6 m (length) x 2.4 m (width) x 0.3 m (height), weighing approximately 54 tonnes (The Nature Conservancy and INSPIRE Environmental, 2021).	The mattress may act as an attachment surface for sessile organisms (e.g., native oysters, mussels, kelps). It may also act as feeding and spawning ground for fish (e.g., Atlantic halibut, Atlantic herring), nursery ground for fish (e.g., Atlantic cod), feeding / spawning ground for skates and shelter for European spiny lobsters.	Ready to be tested Roman Stone Construction Co., (romanstoneco.com) (under license from Subsea Protection Services)
Water replenishment holes						
Add on unit	Water replenishment holes in monopiles		Fixed	The hollow monopile foundations are equipped with numerous water replenishment holes. Initially, this approach was intended to minimise erosion by enabling through flow of water. In the Dutch offshore windfarm Hollandse Kust Zuid all 140 monopiles have four ellipse shaped water replenishment holes of a height 96 cm and width 32 cm. As the scour protection is placed before the monopile, the seafloor inside the monopile is covered in rock protection. Two of the holes are located about 1 m below Mean Sea Level and the remaining two are approximately 2.85 m above the top of the scour protection.	Atlantic cod and other fish species may benefit from the holes in the monopile through provision of shelter and added habitat. The scour protection inside of the turbine foundation will add habitat complexity, offering settlement opportunity (e.g., for sessile filter-feeding organisms), shelter and feeding grounds for a wide array of species.	As the holes are an integrated within the monopile design, this will be agreed with and undertaken by the monopile manufacturer. Water replenishment holes have been incorporated into the Hollandse Kust Zuid, as part of a collaboration between Vattenfall and The Rich North Sea (derijkenoordzee.nl). Holes are also used in the EcoWende offshore wind farm (Hollandse Kust West).

There is already a degree of similarity between the NID options listed above. It should be emphasised that the above list is not exhaustive, there are a number of other available products which are relatively similar structurally or conceptually to those included in Table 1. In addition to the measures included in the above table, the following potential NID options were mentioned or conceived via Hermans *et al.*, (2020) who undertook expert consultations with relevant stakeholders.

- Stable scour protection design – allows for reef formation due to increased settlement success of sessile species due to reduced bed movement of the erosion protection.
- Eco anchoring – designed to be installed with a net system which can be used in seaweed cultivation.
- Hotel for elasmobranchs (Elotel) – a structure that allows elasmobranchs (e.g. dogfish) to attach their eggs.
- Hotel for squids (Sqotel) – a structure that allows squids and cuttlefish to attached their egg capsules.
- Shell / rock glue – using different types of autochthonous material and glue to create a larger, stable structure to provide settlement for reef forming species.
- Reef fields – using triangular or square patterns of low rock berms covering approximately 4 m^2 of seabed per running meter to create a large area of hard substrate with minimal rock consumption.
- Shell substrate - One final notable mention is the application a shell substratum / matrix to encourage settlement of habitat forming species such as the reef forming horse mussel (*Modiolus modiolus)* (Roberts *et al.*, 2011).

There are no existing literature in support of these potential NID options, however many are adaptations of those described in Table 1. Furthermore, a number of the NID options in Table 1 are unlikely to apply exclusively to specific species. Consequently, a number of the NID options in in Table 1 may benefit multiple species throughout trophic levels, e.g., elasmobranch species and squid, as listed above.

3.2 Ecological evidence in support of NID options

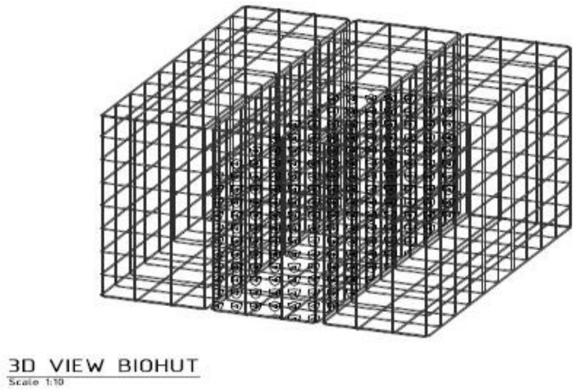
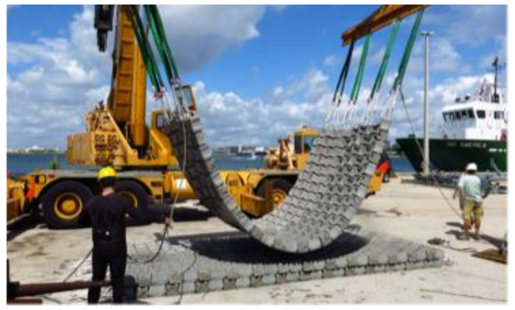
Some of the NID options identified in Section 3.1 have been monitored in terms of their interactions with the biological environment. Table 2 below summarises the available ecological information and findings associated with some NID options. Information has been collated from a range of sources, including unpublished evidence from The Rich North Sea[2], published literature, and directly from suppliers of NID options. It should be mentioned that, in overall, the available evidence about the ecological performance of the NID options is limited; monitoring (in Scottish waters and elsewhere) will be key for advancing understanding about the efficacy of NID options and their potential ecological benefits.

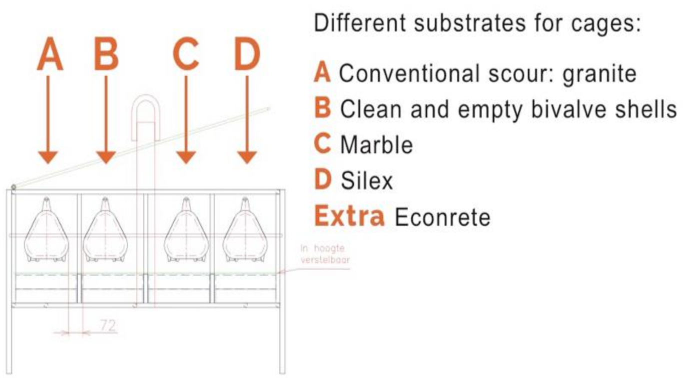
Table 2 Available ecological information from the deployment of identified NID options

NID OPTION	IMAGE	ECOLOGICAL INFORMATION/FINDINGS
Fish Hotel		TenneT, the transmission system operator for the Netherlands, and much of Germany, deployed fish hotels as part of the (now operational) Hollandse Kust Noord offshore wind farm in the Netherlands. The fish hotels were incorporated into the design of the offshore substation. The installation of the fish hotels has been undertaken in collaboration with Ecocean. Monitoring has not taken place yet, there are no published outputs documenting the findings. The robust structure of the fish hotels makes them transferable to most conditions and geographical regions.[3]
Reef Cube		• Hickling *et al.*, (2022) evaluated the effects of different construction materials on the development of macrofouling communities on Reef Cubes®. The deployment occurred in the subtidal zone of Torbay, Devon, UK and lasted for 1 year. • They found no significant differences in species richness, species diversity, total biomass, calcareous mass and live biomass between the different material types. Total live cover was significantly different across different construction materials; cement-limestone blend concrete had the highest values followed by Reef Cubes made of alkali activated slag concrete and Reef Cubes made of cement-limestone blend concrete with an additional micro silica pozzolan and an exposed aggregate texture. According to Hickling *et al.* (2022) a potential explanation for the similarity in biomass but difference in total cover could be the aggregation of biomass in patches (Ly *et al.*, 2021). • Comparisons of community composition between Reef Cubes made of alkali activated slag concrete and cement-limestone blend concrete did not show significant differences; however, both types of Reef Cubes showed significant differences in terms of community composition with Reef Cubes made of cement-limestone blend concrete with an additional micro silica pozzolan and an exposed aggregate texture, which had a higher abundance of erect Bryozoans. Differences in community composition across concrete mixtures are likely as a result of the combined effect of difference in chemistry and surface texture; both can affect the development of epibenthic fouling communities, but the effects of surface texture are stronger (Hayek *et al.*, 2021). • The findings of Hickling *et al.*, (2022) did suggest that alternative construction materials could be satisfactory substrates for the development of epibenthic communities on Reef Cubes®. • Kardinaal (2021) evaluated the effects of Reef Cube deployment on the potential enhancement of reef associated fishes and benthic communities. • They found that there was an enhanced abundance for a number of species, including Ross worm (*S. spinulosa)*, the sand mason worm (*Lanice conchilega*), common mussel (*Mytilus edulis*), oysters (*Ostrea edulis* and *Crassostrea gigas*), crustaceans, including the brown crab (*Cancer pagurus*) and European lobster (*Homarus gammarus*), pouting, common dab, red mullet, gobies, common dragonet, starfish, serpent stars and velvet crabs.

[2] *The Rich North Sea, who have led the development of toolkits on NID in offshore wind farms, have collaborated with Xodus to provide expert advice on the applicability and role of NID in offshore wind.*

[3] *https://renewables-grid.eu/activities/best-practices/database.html?detail=232&cHash=27d024210eb6dd53fc50c9832076f639*

NID OPTION	IMAGE	ECOLOGICAL INFORMATION/FINDINGS
Biohut		• Bouchoucha *et al.* (2016) tested the potential benefit of Biohuts on docks and pontoons to increase their value as fish nursery grounds in the Mediterranean. • A number of fish species were examined: *Diplodus annularis*, *Diplodus puntazzo*, *Diplodus sargus sargus, Diplodus vulgaris*. These are species of high economical value in the area. • Average abundances on added Biohut habitats were twice as high as on nearby bare surfaces. This suggests that increasing the complexity of the vertical structures of marinas can considerably enhance their suitability for juvenile rocky fishes, especially at the youngest stages, when mortality is highest. • Mercader *et al.* (2017) found that, despite limitations of the study, small artificial habitats do enhance the nursery function for juvenile fish in a large commercial port in the Mediterranean through increased habitat complexity. • Selfati *et al.* (2018) also tested the suitability of installing Biohuts in marinas to reinforce the nursery function of the Marchica coastal lagoon in the Mediterranean. • The Biohuts hosted a relatively high density of juvenile dusky and comb groupers in comparison with natural habitats. They can, therefore, be considered as a reservoir for juvenile groupers, including the endangered dusky grouper, and are suitable to reinforce the nursery function of this coastal lagoon.
ECO Mats®		• Sella *et al.* (2021) investigated deployment of Ecological Articulated Concrete Block Mattresses (ACBM) in Port Everglades, Florida which was compared against adjacent artificial structures and smooth surface concrete blocks. • Monitoring took place over a period of two years and found that use of ACBM increased the richness and diversity of sessile assemblages compared to control blocks and adjacent artificial structures. ACBM also supported a higher abundance of mobile species.
Adapted grading armour layer (scour protection)		• Lengkeek *et al.* (2017) reviewed literature of ecological provision of scour protection in the Dutch North Sea. • The number of species on conventional scour protection material that is currently deployed in the North Sea is relatively low compared to other artificial hard substrates. Therefore, they concluded that scour protection in Dutch offshore wind farm offers the potential for improving local ecology. • Kingma *et al.* (2023) examined the effect of substrate material and grading of the scour protection on the benthic biodiversity *in situ* in an offshore wind farm in the Dutch North Sea. • Research cages containing crates with different types of substrates (concrete, granite, and marble) were deployed on scour protection. • The study revealed a significant positive relationship between available substrate surface (pebble size) and taxonomic richness. Living habits also differed between substrate types. • The findings support the value of nature-friendly scour protection designs, emphasizing that both taxonomic and functional diversity will increase by incorporating various substrate types and extending its surface area. • Mirta *et al.* (2020) reviewed available information for offshore wind farms in the North Sea and showed that scour protection layers host diverse and abundant communities of fauna colonising the protection layer. • Comparison of gravel bed communities to those found in scour protection layers showed that there was higher species diversity in natural compared to artificial substrates. • In-situ experiments in the EMBRC-BE Artificial Hard Substrate Garden site in the C-Power offshore wind farm (in Belgium) showed that combining different rock sizes (increasing habitat complexity) had significant and positive effects on species richness and positive effects on the biomass of the community colonising the scour protection layer.

NID OPTION	IMAGE	ECOLOGICAL INFORMATION/FINDINGS
Oyster tables	 	• The Rich North Sea programme has been undertaking research into NID options in the Netherlands. • At the Blauwwind wind farm (Borsele III & IV Netherlands) a survival of 96% of European flat oyster was recorded a year after placement of the oyster tables. Biodiversity was monitored using eDNA traces in the water and an underwater camera. • Didderen *et al.* (2019) monitored a number of (technical and ecological) parameters with deployment of oyster tables. • Inspection of the racks showed very little corrosion. • There was evidence of sand and fouling species covering large parts of the infrastructure. The main fouling species include oaten pipes hydroid (*Tubularia indivisa*) and tube building amphipods (*Jassa* sp.). • Oysters had been alive and increasing in size prior to burial with sand. However, the condition index of the live oysters was significantly lower after the monitoring period (July 2019) than at the start of the investigation (November 2018). This could be in line with the natural seasonal variation. • Rich life around, and at, the introduced structures was observed, i.e. crabs, fish, mussels and squid eggs were seen on all images. Pout (*Trisopterus luscus*), edible crab (*Cancer pagurus*), plumose anemone (*Metrdidium* sp.) and common starfish (*Asterias rubens*) were also observed. • Mobile species like lobsters, starfish and crabs and sessile animals like mussels and anemones were all identified on the structures after their removal. • Monitoring in 2023 showed an average survival of oysters of 74% when compared to the T1 (time point = one year after installation). Young oysters were also found in and around the broodstock structure. No DNA analyses were done to establish genetic origin, however because of the proximity to the broodstock population chances are high these young oysters have been spawned from the placed adults. • In total, 137 taxa (species and higher groups, such as family) were found during the T3 (time point = three years after installation). From the T0 (time point = year of installation) to the T3 there has been a development in species composition and also species cover seems to be increasing over the years. In the T3, the species community is getting more complex when compared to the T0 and T1. This is consistent with the succession from a pioneer community with fewer dominant species towards the development of a more intermediate stage of the species community.
3D printed reefs[4]		• The 3D printed reefs consist of several levels that are connected to each other by hollows where fish can swim in and out of hiding places. At the same time, the structures themselves will provide surfaces and crevices where other organisms can attach. • Ørsted and the World Wide Fund for Nature (WWF Denmark) hope that it will have positive effects on the Kattegat cod stock and in turn contribute to a healthier, more resilient marine ecosystem with improved biodiversity. • The expectation is that the new 3D printed reefs can complement the stone reefs and will quickly become inhabited with life.[5]

[5] https://orsted.com/en/media/news/2022/06/13654370

NID OPTION	IMAGE	ECOLOGICAL INFORMATION/FINDINGS
ExoReef		• Exo-Engineering deployed the novel ExoReef units in September 2021 in the Crouch Estuary, in proximity to Gunfleet Sands Offshore Windfarm off the Essex coast.[6] • The trial provided evidence of the effectiveness of the Greening the Grey® technology, building upon the success of the laboratory testing of these products with the University of Southampton.
ExoReef, ExoHedrons, ExoSpheres, and ExoAnchors		• The first pilot of the Living Windfarms Project began in early September 2023, in the Celtic Sea. In collaboration with floating offshore wind developer Hiraeth Energy, over 16 tonnes of ExoReef units were deployed at an offshore Marine Energy Test Area in East Pickard Bay, off the Pembrokeshire coast.[7] • eDNA sampling will be undertaken and imagery of the site will be collected in order to determine the environmental outcomes associated with the deployed NID options. • The project aims to enable mass production of alternatives to rock as scour protection.

[6] www.exo-engineering.co.uk
[7] https://www.livingwindfarms.com/overview

3.3 Habitats and species in Scotland which may benefit from identified NID options

Habitats and species in Scotland which may benefit from the NID options detailed in Section 3.1 are shown in Table 3.

These species and habitats have been considered here based on the narrative justification provided in Section 2.4 (i.e., are species / habitats policy-important or habitat forming, do they overlap spatially with offshore wind lease sites, are they associated with hard substrates, and are they located at an appropriate depth). Those habitats and species which did not fit the requisite criteria, and consequently are not considered further, can be found in Appendix A. It is important to note that habitats and species that may benefit are fully dependant on the environmental conditions present at the deployment site including water depth, hydrodynamic conditions, the existing substrates present in the area and species distribution. While some of these species will be considered habitat forming and increase biodiversity, it is noted that the primary potential benefits of such NID options will be to lower trophic levels and that the associated productivity is expected to have an indirect positive effect on higher trophic levels (such as predatory arthropods, and fish) through the provision of foraging areas and shelter.

The vast amount of information about the policy frameworks for each habitat and species as well as their habitats requirements and role in ecosystem functioning have been extracted from Tyler-Walters *et al.* (2016).

Table 3 Habitats scoped in; commercially important habitats are marked with an asterisk (*)

HABITATS	POLICY FRAMEWORKS	HABITAT REQUIREMENTS / ROLE IN ECOSYSTEM FUNCTIONING	POTENTIAL BENEFIT FROM NID OPTIONS
Blue mussel beds	• PMF • Habitats Directive Annex I • OSPAR T&D (not all components) • SBL • UK BAP	• Blue mussels (*Mytilus edulis*) are found at various rock and sediment types in the intertidal and subtidal (0-30 m) zones, and in a range of conditions from open coasts to estuaries and marine inlets. • The beds are found in the intertidal or subtidal zones. • They contribute to sediment stabilisation and provide habitat supply for other organisms (Tyler-Walters *et al.*, 2016).	Attachment surface. • Considering that this habitat is recorded in inshore areas in Scotland it is assumed that cable protection NID options (e.g., mattresses, reef cube bags) may supply attachment surfaces.

HABITATS	POLICY FRAMEWORKS	HABITAT REQUIREMENTS / ROLE IN ECOSYSTEM FUNCTIONING	POTENTIAL BENEFIT FROM NID OPTIONS
		• Distribution in Scotland: They are found in scattered locations in the coast, mainly at the head of sea lochs and in the mouths of estuaries and firths.	
Horse mussel beds	• PMF • Habitats Directive Annex I • OSPAR T&D • SBL • UK BAP	• Horse mussel beds (*Modiolus modiolus*) are found in weak to strong water movement on a variety of mixed substrata. Found at depths of 5-220 m. • Horse mussel beds modify sedimentary habitats and supply habitat, refuge to various organisms. They enhance local biodiversity and may provide settling grounds for commercially important bivalves such as queen scallops (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: They are mainly found in the west coast, Orkney and Shetland (sea lochs, embayments and open coast).	Attachment surface. • Considering that this habitat is recorded in inshore areas in Scotland it is assumed that cable protection NID options (e.g., mattresses, reef cube bags) may supply attachment surfaces.
Kelp beds	• Habitats Directive Annex I • PMF • SBL • UK BAP	• Beds of the kelp *Laminaria hyperborea* form as forests and parks in rocky coastal areas, under a variety of wave and tidal conditions. Kelp beds occur in shallow waters (to a maximum of 20-30 m), on bedrock and boulders in a range of wave exposure regimes and tidal conditions. • The kelp provides a canopy under which a wide range of animals and other seaweeds thrive (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: They have a wide distribution across all the coasts of mainland and islands.	Attachment surface • Considering that this habitat is recorded in inshore areas in Scotland it is assumed that cable protection NID options (e.g., mattresses, reef cube bags) may supply attachment surfaces.
***Sabellaria spinulosa* reefs (*Sabellaria spinulosa* on stable circalittoral mixed sediment)**	• OSPAR T&D	• The tube-building polychaete *S. spinulosa* at high abundances on mixed sediment. This species typically forms loose agglomerations of tubes forming a low lying matrix of sand, gravel, mud and tubes on the seabed. • Consolidate the sediment and allow the settlement of other species not found in adjacent habitats leading to a diverse community of epifaunal and infauna species (OSPAR, 2013).	Attachment surface. • Considering the inshore and offshore locations that these habitats have been found in eastern Scotland (see Figure 1 in Pearce and Kimber, 2020) it is assumed that cable protection NID options (e.g., reef cube bags, mattresses), scour protection (e.g., additional rock layer) and standalone units placed

HABITATS	POLICY FRAMEWORKS	HABITAT REQUIREMENTS / ROLE IN ECOSYSTEM FUNCTIONING	POTENTIAL BENEFIT FROM NID OPTIONS
		• Distribution in Scotland: Sites in the east coast of Scotland support areas of reef with most prominent examples being found at the Rattray Head and Southern Trench (Pearce and Kimber, 2020).	around the asset (e.g., reef cubes; Kardinaal, 2021) may supply attachment surfaces.
Tide-swept algal communities	• PMF • Habitats Directive Annex I • SBL • UK BAP	• Sheltered to wave-exposed tidal channels, often at the entrance of, or near to sea lochs, between coastal islands, or between islands and the mainland where tidal flow is funnelled by the shape of the coastline. This habitat can occur from the mid shore down to depths of 30 m, in full or variable salinity. • Found on bedrock and mixed substrata. • The kelps and fucoids form a canopy that provides shelter for an understorey of sheltering plants and animals (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: The habitat has been recorded in the west coast of Scotland, outer Hebrides, Orkney and Shetland.	Attachment surface. • Considering that this habitat is recorded in inshore areas in Scotland it is assumed that cable protection NID options (e.g., mattresses, reef cube bags) may supply attachment surfaces.
Kelp and seaweed communities on sublittoral sediment	• PMF • UK BAP (KSwSS.LsacR.CbPb only • SBL (KSwSS.LsacR.CbPb only)	• Found in shallow water (max. 20 m depth), on a wide variety of substrates (muddy sands and gravels through to cobbles and boulders) and in various environmental conditions. • Shallow sublittoral sediments which support seaweed communities typically include the sugar kelp *Saccharina latissima*, the bootlace weed *Chorda filum* and various red and brown seaweeds, particularly filamentous types. • A diverse array of animals are associated with these kelp and seaweed dominated habitats e.g. burrowing polychaete worms and bivalves, scavenging hermit crabs, crabs, starfish, fish and grazing top shells (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: Mainly found in the west coast of Scotland and in sheltered areas in Orkney and Shetland. Occasionally present in the east coast.	Attachment surface. • Considering that this habitat is mainly recorded in inshore areas in Scotland it is assumed that cable protection NID options (e.g., mattresses, reef cube bags) may supply attachment surfaces.
Kelp in variable or reduced salinity	• PMF • Habitats Directive Annex I	• Very wave sheltered bedrock, cobbles and boulders subject to weak tidal streams in the shallow subtidal, in areas of variable	Attachment surface.

HABITATS	POLICY FRAMEWORKS	HABITAT REQUIREMENTS / ROLE IN ECOSYSTEM FUNCTIONING	POTENTIAL BENEFIT FROM NID OPTIONS
	• SBL • UK BAP	salinity at 0-10 m depth; such as sheltered voes in Shetland, in saline lagoons and at the head of fjardic sea lochs (Tyler-Walters *et al.*, 2016). • The habitat provides shelter and food supply for various organisms. Associated fauna may include grazing urchins and gastropods, tube-dwelling polychaete worms, sea squirts, barnacles, starfish and brittlestars. Crabs and bivalves may also be present. • Distribution in Scotland: This habitat is found in the west coast of Scotland, Hebrides, Shetland and Orkney.	• Considering that this habitat is mainly recorded in inshore areas in Scotland it is assumed that cable protection NID options (e.g., mattresses, cube bags) may supply attachment surfaces.
Ostrea edulis* beds on shallow sublittoral muddy mixed sediment	• PMF • OSPAR T&D • SBL • UK BAP	• A diverse community lives on, amongst, or in the sediment beneath the bed. Dead oysters support sea squirts, sponges, hydroids and a turf of algae. Large polychaete worms are often present, along with predatory fish, starfish and crabs. • Associated with productive estuarine and shallow coastal water habitats on firm mud, muddy sand and muddy gravel with shells and stones. The oyster larvae settle on hard substrates. Sheltered coasts from the intertidal to 5m and occasionally to 20 m. • Dense beds were once common along the coast of Scotland, including Orkney, Shetland and the Firth of Forth. Beds in the Firth of Forth covering 129 km^2 landed 59 million oysters in 1834-36, but by 1957 they were extinct (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: Known only from few areas in the west coast of Scotland (Loch Ryan, Loch Sween and Loch Scridain).	Attachment surface. • Considering that this habitat is mainly recorded in inshore areas it is assumed that cable protection NID options (e.g., mattresses, cube bags) may supply attachment surfaces. Stand alone units designed for oysters (e.g., oyster gabions) can also be considered.
***Caryophyllia smithii* and *Swiftia pallida* on circalittoral rock**	• PMF • Habitats Directive Annex I • SBL • UK BAP	• Dense aggregations of the cup coral *Caryophyllia smithii* with sea fans *Swiftia pallida* on upper and vertical surfaces of bedrock and boulders, in silty sediment, at a depth of 10-50 m. • Much of the rock surface is colonised by encrusting coralline and red seaweeds with barnacles, keel worms, sea mats, sparse sea	Attachment surface. • Considering that this habitat is mainly recorded in inshore areas in Scotland it is assumed that cable protection NID options (e.g., mattresses, cube bags) may supply attachment surfaces.

HABITATS	POLICY FRAMEWORKS	HABITAT REQUIREMENTS / ROLE IN ECOSYSTEM FUNCTIONING	POTENTIAL BENEFIT FROM NID OPTIONS
		firs, soft corals, large sea squirts and feather stars (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: It is found in the west coast (Loch Sunart) and the Outer Hebrides.	
Mixed turf of hydroids and large ascidians with *Swiftia pallida* and *Caryophyllia smithii* on weakly tide-swept circalittoral rock	• PMF • Habitats Directive Annex I • SBL • UK BAP	• Particularly diverse biotope with sea fans *Swiftia pallida*, cup corals *Caryophyllia smithii*, football sea squirts *Diazona violacea*, and numerous solitary sea squirts on the upper and vertical surfaces of bedrock and boulders. In addition to these large conspicuous species, rock surfaces are colonised by rich turf of mixed sea firs and erect sea mats overlying barnacles and encrusting coralline seaweeds. Foliose red and brown algae, axinellid sponges (e.g., the goblet sponge *Phakellia ventilabrum*), feather stars (e.g., northern feather star *Leptometra celtica*) and brachiopods may also be present. Overhangs and crevices shelter the long-clawed squat lobster *Munida rugosa*. Starfish scavenge over the rocks while sea urchins and top shells graze algae and encrusting animals from the rock surfaces. • Found on circalittoral bedrock and boulders on silty sediment which is subject to moderately strong to weak tidal streams in fully marine conditions from 10-40 m (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: There are sparse records from the west coast (e.g., the Firth of Lorn).	Attachment surface. • Considering that this habitat is mainly recorded in inshore areas in Scotland it is assumed that cable protection NID options (e.g., mattresses, cube bags) may supply attachment surfaces.
Submerged fucoids, green or red seaweeds (low salinity infralittoral rock)	• PMF • Habitats Directive Annex I • SBL • UK BAP	• This habitat is found in rocky areas, at low depths (0-5 m) in reduced salinity areas. • This habitat usually hosts few animal species (due to the low salinities) but snails, crabs and shrimps may be hosted (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: There are several records of the habitat in the west coast, the Outer Hebrides, Orkney and Shetland.	Attachment surface. • Considering that this habitat is mainly recorded in inshore areas in Scotland it is assumed that cable protection NID options (e.g., mattresses, cube bags) may supply attachment surfaces.

HABITATS	POLICY FRAMEWORKS	HABITAT REQUIREMENTS / ROLE IN ECOSYSTEM FUNCTIONING	POTENTIAL BENEFIT FROM NID OPTIONS
Deep sponge communities (circalittoral)	• PMF • Habitats Directive Annex I • SBL • UK BAP (DpSp.PhaAxi only)	• Typically occurs on wave-exposed rock subject to very weak-moderate current flow at depths greater than 35 m (Tyler-Walters *et al.*, 2016). • Filter feeders are associated with these sponge communities such as keelworms, encrusting and erect sea mats, and soft corals (e.g., dead man's fingers). Grazing molluscs (including painted top shells) and common sea urchins occur in low numbers, together with larger carnivorous echinoderms; the starfish *Strichastrella rosea* and *Solaster endeca*. Brittlestars and long clawed squat lobsters are widely distributed. • Distribution in Scotland: They have been recorded in offshore waters to the north-east of Shetland and the west of the Hebrides. Inshore, these sponge communities are found off the coast of Mingulay, in The Minch and within the Firth of Lorn.	Attachment surface. • Considering that this habitat is found both in inshore and offshore areas in Scotland it is assumed that scour protection NID options (e.g., scour protection units, mattresses), cable protection (e.g., mattresses, cube bags) and standalone units (e.g., reef cubes, 3D printed units) may supply attachment surfaces.
Annex I Bedrock reef	• Habitats Directive	• Bedrock reefs provides an underwater landscape of hard substrates (e.g., cliffs). Bedrock reefs host various organisms (e.g., encrusting bryozoans, coralline algae, brittle stars, cup corals, jewel anemones, red algae, sponges) (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: Bedrock/stony reefs are found in inshore and offshore areas in Scotland.	Attachment surface
Annex I Stony Reef	• Habitats Directive	• Stony reefs may comprise areas of boulders or cobble (cobbles are generally considered as being between 64 mm and 256 mm in diameter, and boulders as being greater than 256 mm in diameter) which arise from the seafloor and provide a suitable substratum for the attachment of benthic communities of algae (when shallow enough) and animal species (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: Bedrock/stony reefs are found in inshore and offshore areas in Scotland.	Attachment surface

The list of species that have been scoped in can be seen in Table 4 below.

Table 4 Species scoped in, commercially important species are marked with an asterisk (*)

SPECIES	POLICY FRAMEWORKS	HABITAT REQUIREMENTS/ECOLOGY	POTENTIAL BENEFIT FROM NID OPTIONS
Native oyster (*Ostrea edulis*)*	• PMF • OSPAR T&D • SBL • UK BAP	• Associated with firm mud, muddy sand and muddy gravel with shells and stones, in estuarine and shallow coastal water habitats down to 80 m, although more common above 20 m (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: Usually found at sea lochs in the west coast and around Shetland.	Attachment surface. • Considering that this habitat is mainly recorded in inshore areas in Scotland it is assumed that cable protection NID options (e.g., mattresses, cube bags) may supply attachment surfaces. Standalone units designed for oysters (e.g., oyster gabions) can also be considered.
Northern sea fan (*Swiftia pallida*)	• PMF • SBL • UK BAP	• This species is a host for the nationally rare sea fan anemone *Amphianthus dohrnii*. • Generally found in areas of good water movement, attached to rocks and boulders, and at depths of 20 - 60 m (although it has been recorded at over 2000 m). Also found on pebbles and cobbles lying in coarse shell, sand and silt (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: Sea lochs and inlets in the west coast; also in Outer Hebrides and St Kilda.	Attachment surface. • Considering that this habitat is mainly recorded in inshore areas in Scotland it is assumed that cable protection NID options (e.g., mattresses, cube bags) may supply attachment surfaces.
Atlantic halibut (*Hippoglossus hippoglossus*)	• PMF • SBL • UK BAP • IUCN Red List (Endangered)	• A bottom dwelling fish living in temperate areas. Adults are capable of extensive movements using selective tidal stream transport. • Depth range: 50 – 2000 m. • Feeds on marine fish, molluscs and crustaceans. • Spawning happens near the seabed (300 to 700 m) on mud or clay bottoms. • Juveniles are found in in coastal areas 20 - 60 m deep with sandy bottoms. • Usually found on sand, gravel, or clay substrates and not on soft mud or on a rocky seabed (Marlin, 2024; Tyler-Walters *et al.*, 2016). • Distribution in Scotland: Found in all coasts of Scotland and offshore.	Feeding ground. • Considering that i) adult specimens are capable of extensive movements, ii) scour protection, cable protection and standalone NID options may host invertebrates on which halibut feeds on (e.g., molluscs and crustaceans) it is likely that these NID options may serve as a feeding ground.
Atlantic cod (*Gadus morhua*)*	• PMF • OSPAR T&D • SBL • UK BAP	• Cod can be found from the shoreline down to depths of 600 m. • Juveniles prefer shallow (less than 10 - 30 m depth) sublittoral waters with complex habitats, such as seagrass beds, areas with gravel, rocks, or boulder, which provide protection from predators.	Feeding ground / Shelter / Nursery ground • Considering that Atlantic cod is omnivorous and is found from shoreline down to 600 m water depth it is assumed that

SPECIES	POLICY FRAMEWORKS	HABITAT REQUIREMENTS/ECOLOGY	POTENTIAL BENEFIT FROM NID OPTIONS
	• IUCN Red List (Vulnerable)	• Spawning sites are in offshore waters, at or near the bottom, in 50 - 200 m depth and 0-12 °C (FishBase, 2024). • Cod prefer to spawn on harder substrate (coarse sand, gravel) but may also spawn on softer ground (sand, muddy sand, sandy mud). The least preferred sediment type is fine mud, but spawning right next to muddy areas has been observed. There are important spawning grounds to the west and east of Shetland, extending offshore from around Lewis and Harris in the Outer Hebrides, between Islay and Mull and within the Clyde. Coastal nursery areas in the Firths of Clyde, near the Tay, Forth and Moray, supply nearby spawning areas whilst nursery areas around Shetland contribute to both local spawning groups and larger offshore spawning areas in the North Sea. • Omnivorous species which feeds predominantly at dawn or dusk on a variety of invertebrates and marine fish, including young cod, sandeels, Norway pout, herring and whiting (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: Found all around the Scottish coastline and in offshore areas.	invertebrates colonising scour protection, cable protection and standalone units can serve as a food source. • Considering that juveniles occur in shallow coastal areas it is assumed that cable protection options providing holes / shelter spaces (e.g., filter units, basalt bags, reef cube mats) may serve as a nursery ground and shelter for Atlantic cod. • Add on options (e.g., cod hotel, Biohut) may serve as feeding ground and shelter for cod. • Considering the spatial allocation of cod spawning grounds in Scotland and the type of substrate that spawning takes place it is assumed that scour protection options (e.g., additional rock layer, adapted grading armour layer) may supply spawning grounds for this species. • Cod show seasonal increase in abundance in areas with high densities of artificial structures (oil and gas platforms and wrecks (Wright *et al.*, 2018).
Atlantic herring (*Clupea harengus*)	• PMF • SBL • UK BAP • IUCN Red List (Least concern)	• This species is found in shallow waters up to depths of 200 m. The adult specimens spawn on coarse sediments in coastal areas. Juveniles occur in shallower, coastal areas before migrating to deeper waters (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: Found all around the Scottish coastline and in offshore areas.	Spawning ground / Nursery ground / Shelter • Considering that spawning takes place in costal coarse sediments it is assumed that cable protection NID options (e.g., mattresses, cube bags) may serve as a spawning ground for herring. • Considering that juveniles occur in shallow coastal areas it is assumed that cable protection options providing holes / shelter spaces (e.g., filter units, basalt bags, reef cube mats) may serve as a nursery ground and shelter for juvenile herring.
Flapper skate and blue skate (formerly common skate) (*Dipturus batis* complex)	• PMF • OSPAR T&D • SBL • UK BAP • IUCN Red List (Critically endangered)	• The blue skate is found further south in the UK and it is the flapper skate that is predominantly recorded in Scottish waters. • Lives on sandy, muddy and gravel bottoms from the coast down to 600 m. • An opportunistic feeder and scavenger, this species feeds on worms, sandeels, crabs, molluscs and flatfish on the seabed. It is also known to actively hunt fish and smaller elasmobranchs within the water column. • They spawn in boulder and cobble in relatively shallow waters.	Feeding ground / Spawning ground • Considering the bathymetric distribution and diet composition of flapper skate it is assumed that invertebrates found on scour protection, cable protection and standalone units (e.g., worms, crabs, molluscs) may serve as a food source for this species. • Considering that skates spawn on hard substrates in relatively shallow waters it is assumed that cable protection NID options (e.g., matts, reef cube bags) may serve as a spawning ground for them.

SPECIES	POLICY FRAMEWORKS	HABITAT REQUIREMENTS/ECOLOGY	POTENTIAL BENEFIT FROM NID OPTIONS
		• Distribution in Scotland: Several records in the west coast. Found also in Hebrides, Orkney and Shetland. A smaller number of records have been made in the east coast including offshore areas.	
Spotted ray (*Raja montagui*)	• OSPAR T&D	• It is found at depths from 8 to 530 m (MARLIN, 2024). • Adult specimens have a preference for soft sandy substrates. Nursery grounds occur in coastal areas with rocky and sandy substratum. • Eggs are deposited in sandy or muddy flats. • Its diet is composed of crustaceans, polychaetes, teleosts and molluscs. • Distribution in Scotland: Distribution in Scotland: Several records in the west coast. Found also in Hebrides, Orkney and Shetland. A smaller number of records have been made in the east coast including offshore areas.	Nursery ground • Considering that juveniles occur in shallow coastal areas it is assumed that cable protection NID options providing holes / shelter spaces (e.g., filter units, basalt bags, reef cube mats) may serve as nursery ground for spotted ray.
Ling (*Molva molva*)	• PMF • SBL • UK BAP	• Adults are found most commonly in waters between 100 - 400 m in depth associated with rocky reef habitat but may also be encountered in cracks and crevices at depths below 10 m (Marlin, 2024). • Feed mostly on other marine fish such as herring and flatfish but also eat crustaceans and starfish. • Juveniles are found in shallower coastal areas (Marlin, 2024; Tyler-Walters *et al.*, 2016). • Distribution in Scotland: Found all around the Scottish coastline and in offshore areas.	Feeding ground / Shelter / Nursery ground • Considering the bathymetric distribution and diet composition of ling it is assumed that invertebrates found on scour protection, cable protection and standalone units (e.g., crustaceans, echinoderms) may serve as a food source for this species. • Considering that adults specimens may be encountered in cracks and crevices it is assumed that NID options providing this type of microhabitats may serve as a shelter for ling. Specifically these microhabitats may be served by scour protection (e.g., rock layer/armour layer, scour protection units), cable protection (e.g., mattresses, reef cube bags) and standalone NID options (e.g., fish hotel, habitat pipes, reef ball, layer cakes). • Considering that juveniles occur in shallow coastal areas it is assumed that cable protection NID options providing holes / shelter spaces (e.g., filter units, basalt bags, reef cube mats) may serve as a nursery ground for ling.
Saithe (*Pollachius virens*)*	• PMF	• Demersal species with a depth distribution range from 37 to 364 m. • Adult specimens are found offshore while juvenile saithe are found in nearshore waters in habitats ranging from aquatic vegetation to open areas of cobbles, bedrock, and sandy mud substrates.	Feeding ground / Nursery ground • Considering that juvenile specimens feed on crustaceans in nearshore waters it is assumed that cable protection NID

SPECIES	POLICY FRAMEWORKS	HABITAT REQUIREMENTS/ECOLOGY	POTENTIAL BENEFIT FROM NID OPTIONS
		• Adults are distributed across Scotland's seas. Important spawning grounds are known from the west and north-east of Scotland. • Spawning is pelagic and the fertilized eggs ascend to the surface (Olsen *et al.*, 2009) • The adult diet consists mostly of fish, with juveniles feeding on crustaceans and small fish. • Distribution in Scotland: Found all around the coast and in offshore waters.	options hosting these invertebrates (e.g., mattresses, reef cube bags) may serve as a feeding ground for juvenile saithe. • Considering that juveniles occur in shallow coastal areas it is assumed that cable protection options providing holes/shelter spaces (e.g., filter units, basalt bags, reef cube mats) may serve as a nursery ground for saithe.
Spiny dogfish / spurdog (*Squalus acanthias*)	• PMF • OSPAR T&D • SBL • UK BAP • IUCN Red List (Vulnerable)	• Benthopelagic species, found mostly at depths of between 10 - 200 m but can reach depths of up to 900 m. Can form schools of different sex and size. • Limited information about the spawning grounds (Ellis *et al.*, 2012). • Neonate *S. acanthias* prefer fine clay and silt substrate to coarse sandy substrate (Sulikowski *et al.*, 2013). • Feeds on a variety of bony fish and crustaceans. • Distribution in Scotland: Widely distributed throughout Scottish waters.	Feeding ground • Considering the bathymetric distribution of spiny dogfish and the fact that crustaceans are part of its diet, it is assumed that scour protection, cable protection and standalone NID options hosting these invertebrates may serve as a feeding ground for this species.
European spiny lobster (*Palinurus elephas*)*	• PMF • SBL • UK BAP • IUCN Red List (Vulnerable)	• Primarily associated with areas of subtidal rock but can occur on sand, muddy gravels or in seagrass beds. Inshore, they prefer rocky or mixed seabed, rock crevices or boulder holes for protection (NatureScot, 2024). • Usually occurs at depths of 5 - 70 m but can be found at depths of up to 160 m. It migrates seasonally between deep offshore waters in winter and shallower coastal waters in summer. • Feeds at night on echinoderms (starfish and sea urchins), small snails, bivalve molluscs, microalgae, shrimp larvae, sea mats, worms, and detritus. • Eggs are retained on the abdomen of the female for eight months prior to hatching (Hunter, 1999; Mercer, 1973; Tyler-Walters *et al.*, 2016). • Distribution in Scotland: Mainly found in the west and north coasts of Scotland. Records from Orkney and Shetland and occasional records on the east coast.	Feeding ground / Shelter • Considering the behaviour of European spiny lobster and the fact that in Scotland is found in inshore areas it is assumed that cable protection NID options providing holes / shelter spaces (e.g., filter units, basalt bags, reef cube mats) may serve as a shelter for this species. • Considering also European spiny lobster's diet composition (e.g., bivalves, worms, detritus) as well as its presence in inshore areas in Scotland, it is assumed that cable protection NID options hosting these invertebrates (e.g., mattresses, reef cube bags) may serve as a feeding ground for this species.
Northern feather star (*Leptometra celtica*)	• PMF	• Commonly found on sediment, shell, gravel or bedrock from 40 - 200 m but has also been recorded in Scottish sea lochs as shallow as 20 m in areas sheltered from wave action with good water flow. In the right conditions, feather stars can form very dense aggregations making up a significant component of the seabed community. • Feeds on plankton and suspended organic particles (Tyler-Walters *et al.*, 2016).	Attachment surface • Considering that this sessile species can be found on hard substrates in inshore and offshore areas in Scotland, it is assumed that scour protection (e.g., rock layer, armour layer, scour protection units), cable protection (e.g., mattresses, reef cube bags) and standalone NID options (reef cubes, 3D printed

SPECIES	POLICY FRAMEWORKS	HABITAT REQUIREMENTS/ECOLOGY	POTENTIAL BENEFIT FROM NID OPTIONS
		• Distribution in Scotland: Inshore and offshore areas. Western and northern Scotland from west Shetland, the Minches, south to the Sound of Jura, and offshore Rockall Bank and Stanton Banks.	infrastructure, armour blocks) may supply attachment surfaces for northern feather stars.
Pink sea fingers (*Alcyonium hibernicum*)	• PMF	• Found on shaded vertical or overhanging rock surfaces between 1 - 30 m depth, in areas of good water movement where overhangs provide some shelter from wave action. • Grows in small colonies forming pink, thick, fleshy masses of irregular shaped, stout, finger-like projections (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: Recorded from the west coast (Firth of Lorn, Sound of Mull, Isle of Muck) and St Kilda.	Attachment surface • Considering that this sessile species is mainly found in inshore areas in Scotland, it is assumed that cable protection NID options (e.g., mattresses, reef cube bags) may supply attachment surfaces for pink sea fingers.
White cluster anemone (*Parazoanthus anguicomus*)	• PMF	• Grows on other species (e.g., sponges, worm tubes, sea squirts and hard corals such as *Lophelia pertusa* – now known as *Desmophyllum pertusum*) and on bedrock, boulders and wrecks. Often recorded in dark places such as overhangs or cave roofs that are sheltered from wave action. • It is usually found at depths of at least 400 m but can occur as shallow as 20 m. • Forms small clusters. • Feeds on plankton and suspended organic particles (Tyler-Walters *et al.*, 2016). • Distribution in Scotland: Primarily on the west coast and around the Hebrides – scattered records in east and west coast of Shetland, and east coast of Scotland.	Attachment surface • Considering that this sessile species is mainly found in inshore areas in Scotland, it is assumed that cable protection NID options (e.g., mattresses, reef cube bags) may supply attachment surfaces for these anemones.
Dog whelk (*Nucella lapillus*)	• OSPAR T&D	• Found on wave exposed to sheltered rocky shores from the mid shore downwards. Found usually in the intertidal zone. Rarely present in the sublittoral but may be abundant in areas exposed to extremely strong tidal stress. • Common on all rocky coasts of Britain and Ireland. • They are gregarious specimens and common amongst barnacles and mussels on which they feed. • The egg capsules of *Nucella lapillus* are vase shaped, about 8mm high, usually yellow, and found attached to hard substrata in crevices and under overhangs (Tyler-Walters *et al.*, 2016). • The young feed on unfertilised eggs (Scottish Wildlife Trust, 2024). • Distribution in Scotland: Found in the west coast, Hebrides, Orkney, Shetland and east coast of Shetland.	Attachment surface / Feeding ground / Spawning ground • Considering the presence of dog whelk in inshore areas in Scotland and its diet composition (molluscs, barnacles) it is assumed that cable protection NID options hosting these invertebrates (e.g., matts, reef cube bags) may serve as a feeding ground for dog whelk. • Considering that dog whelk is found on/sheds its eggs on rocky substrates it is assumed that cable protection NID options may also serve as attachment surfaces and spawning ground for this species.

4 CONCLUSIONS AND NEXT STEPS

The literature review has identified a number of NID options that are potentially ecologically relevant for offshore wind farms in Scotland. The identified NID options were associated with hard substrates and were grouped into five categories:

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

A number of NID options are similar structurally and in terms of the functions they provide.

It is suggested that the identified NID options may benefit 14 habitat-forming species and 15 policy-important habitats / species in Scotland. The identified NID options may benefit habitats and species through various ways e.g., acting as attachment surfaces for sessile invertebrates, feeding and spawning ground for fish, nursery grounds for fish, shelter for lobsters.

The identified NID options and the acquired ecological information will be used in the upcoming CEMNID Project deliverables, in particular the SWOT analysis which aims to analyse the identified NID options for their applicability to offshore wind in Scotland, in particular ScotWind. The analysis will consider factors beyond the ecological suitability; the analysis will consider engineering, supply chain, commercial, consenting, policy and all other relevant factors across construction, operation and maintenance and decommissioning phases. The findings of the analysis will be documented in a supporting NID suitability review. While the focus of this literature review has been on the suitability of NID options in Scotland from an ecological perspective, subsequent steps in the Project will consider the technical feasibility of these options in the Scottish context; for instance, factors such as water depth and technical risks associated with installation are relevant to consideration of NID options.

The SWOT analysis approach will consider the following:

1) Ecological services (e.g., habitat supply, feeding ground, spawning ground, nursery ground, shelter) provided from each of the identified NID options;
2) Ecological and technical risks associated with NID options;
3) Universal applicability of NID options across a variety of environmental conditions (i.e. water depth, substrate type, hydrodynamic conditions);
4) Installation, maintenance and decommissioning practicalities;
5) Feasibility for retrofitting NID options in existing offshore wind developments;
6) Implications for commercial fishing activity;
7) Monitoring commitments associated with the NID option.

The list of identified NID options can then be used for offshore wind farm developers in Scotland as a starting point to consider which NID option may be most suitable for offshore wind developments.

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APPENDIX A

Based on the justification provided in Section 2.4, these habitats have been scoped out of further consideration (Table 5).

Table 5 Habitats/biotopes scoped out

HABITATS/BIOTOPES	JUSTIFICATION	POLICY FRAMEWORK
Burrowed mud* (Seapens and burrowing megafauna in circalittoral fine mud)	Associated with soft sediments.	PMF, OSPAR T&D
Burrowed mud* (Burrowing megafauna and *Maxmuelleria lankesteri* in circalittoral mud)	Associated with soft sediments.	PMF
Burrowed mud (Mud burrowing amphipod)	Associated with soft sediments.	PMF
Carbonate mound communities	No overlap with offshore wind lease sites in Scotland.	PMF, OSPAR T&D, SBL, UK BAP
Coral gardens	No overlap with offshore wind lease sites in Scotland.	PMF, OSPAR T&D
Cold water coral reefs	No overlap with offshore wind lease sites in Scotland.	PMF, OSPAR T&D, Habitats Directive Annex I, SBL, UK BAP, CITES Appendix II
Deep-sea sponge aggregations	Occur offshore in water depths of between 250 and 1300 m.	PMF, OSPAR T&D, Habitats Directive Annex I, SBL, UK BAP
Faunal communities on variable or reduced salinity infralittoral rock	No overlap with offshore wind lease sites in Scotland.	PMF, Habitats Directive Annex I, SBL (IFaVS.MytRS only)
Flame shell beds	No overlap with offshore wind lease sites in Scotland.	PMF, SBL, UK BAP
Haploops (*Haploops* spp. communities or habitats)	Associated with soft sediments.	OSPAR T&D
Inshore deep mud with burrowing heart urchins (*Brissopsis lyrifera* and *Amphiura chiajei* in circalittoral mud)	Associated with soft sediments.	PMF

HABITATS/BIOTOPES	JUSTIFICATION	POLICY FRAMEWORK
Intertidal mudflats and sandflats	Associated with soft sediments.	Habitats Directive Annex I, PMF, OSPAR T&D
Littoral chalk communities	Associated with vertical cliffs/supralittoral zone - they are not expected to benefit from the identified NID options .	OSPAR T&D
Maerl beds	Associated with soft sediments.	PMF, OSPAR T&D, Habitats Directive Annex I, SBL, UK BAP
Sublittoral mud in low or reduced salinity (lagoons)	Associated with soft sediments.	PMF
Burrowed mud (Tall seapen)	Associated with soft sediments.	PMF
Burrowed mud (Fireworks anemone)	Associated with soft sediments.	PMF
Low or variable salinity habitats (Sublittoral mud in low or reduced salinity (lagoons))	Associated with soft sediments / brackish waters.	PMF
Low or variable salinity habitats (Small brackish water snail (*Hydrobia acuta neglecta*))	Associated with brackish waters.	PMF
Neopentadactyla mixta in circalittoral shell gravel or coarse sand	The sea cucumbers bury in the sediment during winter months; this behaviour looks not compatible with the hard substrate structure of the NID options.	PMF, Habitats Directive Annex I, SBL, UK BAP
Ocean ridges with hydrothermal vents	Associated with geological/geothermal activity; they are not expected to benefit from the identified NID options.	OSPAR T&D
Offshore deep sea muds* (*Ampharete falcata* turf with *Parvicardium ovale* on cohesive muddy sediment near margins of deep stratified seas)	Associated with soft sediments.	PMF
Offshore deep sea muds (Foraminiferans and *Thyasira* sp. in deep circalittoral fine mud)	Associated with soft sediments.	PMF
Offshore deep sea muds (*Levinsenia gracilis* and *Heteromastus filifirmis* in offshore circalittoral mud and sandy mud)	Associated with soft sediments.	PMF

HABITATS/BIOTOPES	JUSTIFICATION	POLICY FRAMEWORK
Offshore deep sea muds (*Paramphinome jeffreysii*, *Thyasira* spp. and *Amphiura filiformis* in offshore circalittoral sandy mud)	Associated with soft sediments.	PMF
Offshore deep sea mud (*Myrtea spinifera* and polychaetes in offshore circalittoral sandy mud)	Associated with soft sediments.	PMF
Offshore subtidal sands and gravels (*Glycera lapidum*, *Thyasira* spp. and *Amythasides macroglossus* in offshore gravelly sand)	Associated with soft sediments.	PMF
Offshore subtidal sands and gravels (*Hesionura elongata* and *Protodorvillea kefersteini* in offshore coarse sand)	Associated with soft sediments.	PMF
Offshore subtidal sands and gravels (*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand)	Associated with soft sediments.	PMF
Offshore subtidal sands and gravels (*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand)	Associated with soft sediments.	PMF
Offshore subtidal sands and gravels (*Maldanid polychaetes* and *Eudorellopsis deformis* in offshore circalittoral sand or muddy sand)	Associated with soft sediments.	PMF
Offshore subtidal sands and gravels (*Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand)	Associated with soft sediments.	PMF
Sabellaria spinulosa reefs (*Sabellaria spinulosa* encrusted circalittoral rock)	Based on the available literature (Pearce and Kimber, 2020) it seems that this habitat has not been confirmed in Scottish waters.	OSPAR T&D
Sandbanks which are slightly covered by sea water all the time	Associated with soft sediments.	Habitats Directive Annex I
Seagrass beds (*Zostera noltii* beds in littoral muddy sand)	Associated with soft sediments.	PMF
Seagrass beds (*Zostera marina/angustifolia* beds on lower shore clean or muddy sand)	Associated with soft sediments.	PMF

HABITATS/BIOTOPES	JUSTIFICATION	POLICY FRAMEWORK
Seagrass beds (*Zostera marina/angustifolia* beds on infralittoral clean or muddy sand)	Associated with soft sediments.	PMF
Seagrass beds (*Ruppia maritima* in reduced salinity infralittoral muddy sand)	Associated with soft sediments.	PMF
Seamount communities	No overlap with offshore wind lease sites in Scotland.	PMF, OSPAR T&D, SBL, UK BAP
Submarine structures made by leaking gases	Associated with geomicrobiological activity; they are not expected to benefit from the identified NID options.	OSPAR T&D, Habitats Directive Annex I
Tide-swept coarse sands with burrowing bivalves (*Moerella* spp. with venerid bivalves in infralittoral gravelly sand)	Associated with soft sediments.	PMF
Serpulid aggregations	No overlap with offshore wind lease sites in Scotland.	PMF, Habitats Directive Annex I

Based on the justification provided in Section 2.4, these species have been scoped out of further consideration (Table 6).

Table 6 Species scoped out

SPECIES	JUSTIFICATION	POLICY FRAMEWORK
Allis shad (*Alosa alosa*)	Associated with pelagic habitats.	OSPAR T&D, Wildlife and Countryside Act 1981 Schedule V
Angel shark (*Squatina squatina*)	Very limited / no records in Scotland.	OSPAR T&D
Anglerfish (*Lophius piscatorius*)	Associated with soft sediments.	PMF, SBL, UK BAP, IUCN Red List (Least concern)

SPECIES	JUSTIFICATION	POLICY FRAMEWORK
Atlantic mackerel (*Scomber scombrus*)	Associated with pelagic habitats.	PMF, SBL, UK BAP, IUCN Red List (Least concern)
Atlantic salmon (*Salmo salar*)	Associated both with freshwater and marine habitats; the movements of post-smolt and the distribution and habits of salmon while they are at sea are poorly understood (Cefas, 2024) and thus it is unclear how NID can benefit the marine part of its life cycle.	PMF, OSPAR T&D
Azorean barnacle (*Megabalanus azoricus*)	No records in Scotland.	OSPAR T&D
Azorean limpet (*Patella ulyssiponensis aspera*)	No records in Scotland.	OSPAR T&D
Basking shark (*Cetorhinus maximus*)	Associated with pelagic habitats; feeds on plankton.	PMF, OSPAR T&D, SBL, UK BAP, IUCN Red list (Vulnerable), Wildlife and Countryside Act 1981 Schedule V, CITES Appendix II
Bird's nest stonewort (*Tolypella nidifica*)	Associated with brackish habitats.	PMF, SBL, UK BAP, GB Red List - Endangered
Baltic stonewort (*Chara baltica*)	Associated with brackish habitats.	PMF, SBL, UK BAP, GB Red List - Vulnerable
Black scabbardfish (*Aphanopus carbo*)	Associated with pelagic habitats.	PMF, SBL, UK BAP
Bluefin tuna (*Thunnus thynnus*)	Infrequent records in Scotland.	OSPAR T&D

SPECIES	JUSTIFICATION	POLICY FRAMEWORK
Blue ling (*Molva dypterygia*)	Associated with deep waters (usually found on the continental slope at depths of between 300-500 m, often on muddy bottoms; Tyler-Walters *et al.*, 2016).	PMF, SBL, UK BAP, IUCN Red List (Least concern)
Blue whale (*Balaenoptera musculus*)	Associated with pelagic habitats; feeds on krill (Tyler-Walters *et al*,, 2016).	OSPAR T& D, UK BAP, Bern Convention Appendix II, CITES Appendix I, Red List (Near Threatened in Europe/ Endangered globally)
Blue whiting (*Micromesistius poutassou*)	Associated with deep waters (found on the continental shelf and slope and the open ocean to depths of more than 1000 m, but most frequently at between 300-400 m; Tyler-Walters *et al.*, 2016).	PMF, SBL, UK BAP
Bowhead whale (*Balena mysticetus*)	No records in Scotland.	OSPAR T&D
Brook lamprey (*Lampetra planeri*)	Associated with freshwater habitats.	Habitats Directive Annex II
Burrowing sea anemone (*Arachnanthus sarsi*)	Associated with soft sediments.	PMF
European eel (*Anguilla Anguilla*)	Associated both with freshwater and marine habitats; unclear how NID can benefit the marine part of its life cycle.	PMF, OSPAR T&D, SBL, UK BAP, IUCN Red List (Critically endangered), CITES Appendix II
European river lamprey (*Lampetra fluviatilis*)	Associated both with freshwater and marine habitats; unclear how NID can benefit the marine part of its life cycle.	PMF, Habitats Directive (Annexes II & V in fresh water), SBL, UK BA, IUCN Red List (Least concern)
Fan mussel (*Atrina fragilis*)	Associated with soft sediments.	PMF

SPECIES	JUSTIFICATION	POLICY FRAMEWORK
Fin whale (*Balaenoptera physalus*)	Associated with deep waters (most commonly recorded in deep waters of 400 - 2000 m depth beyond the edge of the continental shelf. In Europe the species is usually found in water depths >500 m; Tyler-Walters *et al.*, 2016).	PMF, Habitats Directive Annex IV, SBL, UK BAP, IUCN Red List (Endangered) Wildlife and Countryside Act 1981 Schedule V, CITES Appendix I
Foxtail stonewort (*Lamprothamnium papulosum*)	Associated with brackish habitats.	PMF, SBL, UK BAP, GB Red List - Near threatened, Wildlife and Countryside Act 1981 Schedule 8
Greenland halibut (*Reinhardtius hippoglossoides*)	Associated with deep waters (at depths from 200-2000 m; Tyler-Walters *et al.*, 2016).	PMF, SBL, UK BAP
Gulper shark (*Centrophorus granulosus*)	No records in Scotland.	OSPAR T&D
Heart cockle (*Glossus humanus*)	Associated with soft sediments.	PMF
Houting (*Coregonus lavaretus oxyrinchus*)	Associated with freshwater habitats.	OSPAR T&D
Horse mackerel (*Trachurus trachurus*)	Associated with pelagic habitats.	PMF, UK BAP, IUCN Red List (Vulnerable)
Killer whale (*Orcinus orca*)	Associated with pelagic habitats (occurs in areas of open coast, straits / sounds, sea lochs and offshore. Most commonly sighted at higher latitudes. Normally preferring depths of 20 to 60 m - they also visit shallow waters along coastlines or dive to 300 m in search of food; Tyler-Walters *et al.*, 2016; Animal Diversity Web, 2024).	PMF, Habitats Directive Annex IV, SBL, UK BAP, IUCN Red List (Data deficient), Wildlife and Countryside Act 1981 Schedule V, CITES Appendix II, ASCOBANS

SPECIES	JUSTIFICATION	POLICY FRAMEWORK
Leafscale gulper shark (*Centrophorus squamosus*)	Associated with deep waters (continental slopes, rarely above depths of 500 m, but they do range between 230 - 3300 m; Tyler-Walters *et al.*, 2016).	PMF, OSPAR T&D, SBL, UK BAP, IUCN Red List (Vulnerable)
Leatherback turtle (*Dermochelys coriacea*)	Associated with pelagic habitats (leatherbacks extensive migrations to British waters are to follow swarms of jellyfish which are their main pry item (MARLIN, 2024); it is unclear how leatherback turtle can benefit from the identified NID options).	OSPAR T&D, Habitats Directive Annex IV, IUCN Red List (Critically Endangered), SBL, UK BAP CITES Appendix I, Bern Convention Appendix II, Bonn Convention Appendices I and II
Loggerhead Turtle (*Caretta caretta*)	Young juveniles are typically found among drifting *Sargassum* mats in warm ocean currents (Animal Diversity Web 2024). Adults can often be found basking near the surface in the open ocean (MARLIN, 2024); it is unclear how it can benefit from the identified NID options.	OSPAR T&D, Habitats Directive Annex II, SBL, UK BAP, IUCN Red List (Endangered), CITES Appendix I, Convention of Migratory Species Appendix I and II, Bern Convention Appendix II, Wildlife and Countryside Act 1981 Schedule 5
Long-finned pilot whale (*Globicephala melas*)	Associated with deep waters (usually found in waters 200 - 3000 m deep).	PMF, Habitats Directive Annex IV, SBL, UK BAP, IUCN Red List (Data deficient), Wildlife and Countryside Act 1981 Schedule V, CITES Appendix II, ASCOBANS
Long-snouted seahorse (*Hippocampus guttulatus*)	No records in Scotland.	OSPAR T&D
Minke whale (*Balaenoptera acutorostrata*)	They have a varied diet, feeding on smaller fish (sandeels, herring, sprat, haddock, saithe, whiting, small cod, krill, other plankton); unclear how it can benefit from the identified NID options.	PMF, Habitats Directive Annex IV, SBL, UK BAP, IUCN Red List (Least concern), Wildlife and Countryside Act 1981 Schedule V, CITES Appendix I

SPECIES	JUSTIFICATION	POLICY FRAMEWORK
Northern bottlenose whale *(Hyperoodon ampullatus)*	Associated with deep waters (generally over 500 - 1500 m in depth; Tyler-Walters *et al.*, 2016).	PMF, Habitats Directive Annex IV, SBL, UK BAP, IUCN Red List (Data deficient), Wildlife and Countryside Act 1981 Schedule V, CITES Appendix I, ASCOBANS
Northern Right Whale (*Eubalena glacialis*)	Associated with pelagic habitats; feeds on plankton (Tyler-Walters *et al.*, 2016).	OSPAR T&D
Norway pout (*Trisopterus esmarkii*)	Associated with soft sediments.	PMF
Ocean quahog (*Arctica islandica*)	Associated with soft sediments.	PMF, OSPAR T&D
Orange roughy (*Hoplostethus atlanticus*)	Associated with deep waters (over the continental slope between 150 - 1800 m but generally deeper than 1000 m; Tyler-Walters *et al.*, 2016).	PMF, OSPAR T&D, SBL, UK BAP
Porbeagle shark (*Lamna nasus*)	Associated with pelagic habitats.	PMF, OSPAR T&D, SBL, UK BAP, IUCN Red List (Vulnerable), CITES Appendix II & III
Portuguese dogfish (*Centroscymnus coelolepis*)	Associated with deep waters (found between 400 - 3600 m on the continental slope and the abyssal plains; Tyler-Walters *et al.*, 2016).	PMF, OSPAR T&D, SBL, UK BAP, IUCN Red List (Near threatened)
Risso's dolphin (*Grampus griseus*)	They have an apparent preference for steep seabed habitats, e.g., the edge of the continental shelf between 400 - 1000 m deep and are typically found on the Scottish west coast (Tyler-Walters *et al.*, 2016).	PMF, Habitats Directive Annex IV, SBL, UK BAP, IUCN Red List (Least concern), Wildlife and Countryside Act 1981 Schedule V
Round-nose grenadier	Associated with deep waters (most abundant between about 1000 and 1500 m; Tyler-Walters *et al.*, 2016).	PMF, SBL, UK BAP, IUCN Critically endangered

SPECIES	JUSTIFICATION	POLICY FRAMEWORK
(*Coryphaenoides rupestris*)		
Sandeels (*Ammodytes marinus / Ammodytes tobianus*)	Associated with soft sediments.	PMF
Sand goby (*Pomatoschistus minutus*)	Associated with soft sediments.	PMF
Sandy ray (*Leucoraja circularis*)	Associated with soft sediments.	PMF
Sea lamprey (*Petromyzon marinus*)	Associated both with freshwater and marine habitats. Adult specimens at sea prey on a wide variety of fish through hematophagy; unclear how NID can benefit the marine part of its life cycle.	PMF, OSPAR T&D, Habitats Directive (Annex II in freshwater), SBL, UK BAP, IUCN Red List (Least concern)
Sea trout (*Salmo trutta*)	Associated both with freshwater and marine habitats. Marine polychaetes and terrestrial wind-blown insects may be captured more often by sea trout in estuarine and shallow littoral habitats, whereas fish are more common prey items for trout in pelagic open waters (Thorstad *et al.*, 2016); it is unclear how NID can benefit the marine part of its life cycle.	PMF, SBL, UK BAP, IUCN Red List (Least concern)
Short-snouted seahorse (*Hippocampus hippocampus*)	No records in Scotland.	OSPAR T&D
Sowerby's beaked whale (*Mesoplodon bidens*)	Associated with deep waters (occurs almost exclusively in deep waters beyond the continental shelf edge; Tyler-Walters *et al.*, 2016).	PMF, Habitats Directive Annex IV, SBL, UK BAP, IUCN Red List (Data deficient), Wildlife and

SPECIES	JUSTIFICATION	POLICY FRAMEWORK
		Countryside Act 1981 Schedule V, CITES Appendix II, ASCOBANS
Sperm whale (*Physeter macrocephalus*)	Associated with deep waters (typically found in continental slope and oceanic waters of depths greater than 1000 m).	PMF, Habitats Directive Annex IV, SBL, UK BAP, IUCN Red List (Vulnerable), Wildlife and Countryside Act 1981 Schedule V, CITES Appendix I
Sparling (*Osmerus eperlanus*)	Occurs in coastal and estuarine areas, in midwaters and rarely far from shore. It migrates into rivers to spawn depositing eggs on sandy or gravelly substrates and vegetation (Tyler-Walters *et al.*, 2016; FishBase, 2024); unclear how NID can benefit the marine part of its life cycle.	PMF, SBL, UK BAP, IUCN Red List (Least concern)
Sturgeon (*Acipenser sturio*)	Very limited records in Scotland; associated with rivers and inshore waters.	OSPAR T&D
Thornback skate / ray (*Raja clavata*)	Associated with soft sediments (found on a wide variety of grounds from mud, sand, shingle and gravel. It is less frequently recorded on coarser sediment types. They are also found on patches of sediment among rocky outcrops and boulders) (Tyler-Walters *et al.*, 2016).	OSPAR T&D
White skate (*Rostroraja alba*)	Very limited / no records in Scotland.	OSPAR T&D