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26 August 2024

British Standards Institute (BSI)
389 Chiswick High Road
London, W4 4AL

Dear Jon Kirke,

Response to: British Standards Institute (BSI) PAS 1401:2025 Nature-inclusive marine structures – Code of practice consultation (July 22, 2024)

Scottish Renewables (SR) is the voice of Scotland's renewable energy industry. Our vision is for Scotland to lead the world in renewable energy. We work to grow Scotland's renewable energy sector and sustain its position at the forefront of the global clean energy industry. We represent over 350 organisations that deliver investment, jobs, social benefits and reduce the carbon emissions that cause climate change.

Our members work across all renewable technologies in Scotland, the UK, Europe and around the world, ranging from energy suppliers, operators and manufacturers to small developers, installers, and community groups, as well as companies throughout the supply chain. In representing them, we aim to lead and inform the debate on how the growth of renewable energy can provide solutions to help sustainability heat and power Scotland's homes and businesses.

SR welcomes the opportunity to provide the views of our members to the British Standards Institute's consultation on PAS 1401:2025 Nature-inclusive marine structures – Code of Practice. This consultation is very timely, as it overlaps with the recent publication of reporting from the Collaboration for Environmental Mitigation and Nature Inclusive Design (CEMNID) (August 07, 2024) which has been supported by Scottish Renewables.

Our members recognise that the intrinsically linked twin crises of climate change and biodiversity loss are the greatest environmental challenges of our era and welcome the use of nature-inclusive marine structures in the development of renewable energy. Incorporating nature-inclusive marine structures into offshore renewable energy developments is an effective way to tackle these crises simultaneously, and offshore wind development must not be inhibited by these structures.

The CEMNID project was established in May 2023 to address the twin climate and nature crises by bringing together experts from Scotland's offshore wind sector, consenting bodies and consultees to address key environmental uncertainties which together pose a key barrier to the consenting and deployment of offshore wind. One of the aims of the CEMNID project was to expedite the incorporation of nature-inclusive design principles and measures into planned Scottish offshore wind farms. Relevant outputs from the project include:

- Identification of the principles of Nature Inclusive Design (NID) for offshore wind development, including how these relate to the mitigation hierarchy;
- Considering ecologically promising and practically applicable NID measures that could be applied to Scottish offshore wind projects; and,
- Provide evidence to support the development and application of biodiversity enhancement policies in the consenting of infrastructure in the marine environment.

The outputs from the CEMNID project provide a set of tools, including a suitability review of Nature Inclusive Design measures and a structured process for considering NID options in offshore wind development, which offer a practical framework to deliver vital clean energy projects in ways which benefit the marine environment. We would encourage the British Standards Institute to review the CEMNID project outputs and have regard to existing NID-related resources when finalising PAS 1401:2025.

In responding to this consultation, our members highlight the following key points:

- **Timeline for consideration of Nature-Inclusive Design (NID):** Our members agree with the statement made in Chapter 4.2 that NID options should be considered throughout a project's lifecycle, including in early-stage development (i.e. pre-consent). The guidance could usefully provide further clarity on timelines and opportunities for different NID considerations at specific project stages e.g. Pre-consent, Post-consent, Project Delivery, Operation and Decommissioning. It may be helpful to include an infographic to aid the visualisation of NID considerations throughout an indicative project timeline. Further, significant emphasis is placed on assessing NID proposals within Environmental Impact Assessment (EIA)/planning applications. Due to the Rochdale envelope approach used in offshore wind, the EIA/planning stage is too early to meaningfully consider NID (other than principles). NID details would typically come later once detailed design work is being progressed.
- **Definition of NID:** The current NID definition is geared more toward habitation creation which means typical NID for offshore wind (cable burial, scour protection) is hard to align with the guidance.
- **Decommissioning:** Our members agree that NID should not be considered after windfarm decommissioning except to understand if it is still delivering its objectives and, therefore, does not need to be redelivered if the offshore wind development is being repowered or life extended. We recommend that the guidance acknowledges that, for sectors yet to undertake decommissioning at scale (including offshore wind), limited information is available regarding the feasibility and environmental impacts of undertaking a range of potential decommissioning strategies (e.g. ranging from full infrastructure removal to repowering or site re-use). Environmental outcomes from decommissioning are likely to differ between sectors and locations, such that this guidance should not promote a rigid approach. The guidance should, however, recognise that, where NID measures have been deployed as part of projects, any expectation of full removal is likely to result in the loss of accrued ecological benefits.
- **Monitoring and Evaluation:** SR members recognise the need to protect the integrity of BSI best practice guidance and to avoid the misrepresentation of NID benefits. However, we recommend this guidance avoids setting a rigid and potentially disproportionate requirement for monitoring on every project where NID is proposed, especially where NID measures have already been subject to trials or previous monitoring. Our members note that emphasis is placed on using metrics to measure NID scheme success. Without industry standards in place for marine net gain (MNG), this risks different projects taking different approaches, which would make it difficult to compare success between schemes. To maximise resource efficiency and value, monitoring expectations should be focused on new or novel measures when NID measures are deployed in order to comply with a mandated policy requirement.
- **Costs:** Our members welcome the substantial focus on monitoring in the consultation and recognise how important it is to track the effects of renewable developments on biodiversity and habitats; however, cost and resources must be considered. Further, there is a lack of clarity and detail on costs provided in the consultation, are companies expected to work nature-inclusive marine structures into their project budgets? This will have an impact on project economics and investment confidence.
- **Proportionate risk assessment:** SR members caution that MCDA methods may be inappropriate where limited evidence is available regarding NID efficacy or prior use. The CEMNID project encountered this limitation and opted to utilise a more simplistic Strengths, Weaknesses, Opportunities & Threats (SWOT) framework whilst developing a structured process to consider NID options against a consistent suite of criteria. For objectivity, any application of MCDA methods should ensure that a proportionate level of effort and detail is applied to each perceived risk or assessment category.
- **Principles of nature-inclusive design:** Principle 4 – Collaboration: This principle is less developed within the guidance compared with others and would benefit from examples of the recommended inter-disciplinary collaboration, such as recently demonstrated through the CEMNID project.

It is trusted that our members' feedback will be fully considered. Our members agreed that while PAS 1401:2025 is well intended and there are opportunities within NID, it comes too prematurely. There is consensus around inconsistencies within the document, particularly around the mitigation hierarchy and how it coincides with MNG.

Scottish Renewables members are keen to engage further in discussions about the best way to incorporate nature-inclusive structures so that climate targets can still be achieved, as well as providing favourable conditions for biodiversity to flourish in tandem with renewable developments.

Yours sincerely,

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Scottish Renewables

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PAS 1401:2025, ***Nature-inclusive marine structures - Code of practice***

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Contents

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Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

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0 Introduction

Nature-inclusive marine structures are constructions that consider the needs of marine habitats and species by design. The process of creating such structures, through nature-inclusive design, functions to incorporate the living needs of marine habitats and species into marine construction projects. Humans are driven to place structures in the marine environment by necessity and opportunity. Placement of structures has and will undoubtedly affect marine natural habitats. Nature-inclusive design is an emerging discipline, arising as part of a broader movement towards eco-centric development practices and backed by decades of scientific, ecological engineering research. By incorporating the needs of other species with nature-inclusive design, anthropogenic habitat alterations with marine structures can be improved to foster greater biodiversity than with structures devoid of nature-inclusive design; and to promote vibrant, resilient ecosystems to exist amidst human infrastructure.

For example, a simple nature-inclusive design modification of solid structures is to include hollow spaces that connect to the underlying substrate, which can help to significantly reduce the loss of underlying habitats by placement of the structures, whilst providing additional refuge spaces for marine organisms.

The earth is in the grips of climate and biodiversity crises, with nature declining at an unprecedented rate, never before seen in human history [1]. Conservative estimates suggest that the recent historic species extinction rate is up to 100 times that of the prehistoric “background” extinction rate, in a global phenomenon being labelled a human-caused extinction crisis [2]. Moreover, estimates suggest that two-thirds of the marine environment is now significantly altered by human actions [1].

Incorporating nature-inclusive structures with marine construction projects is one of the most feasible and practical remedial actions to support biodiversity recovery within the complex marine systems ~~that~~ these crises are occurring.

At the same time, nature-inclusive design should not compromise the efficacy and safety of structures for their intended purpose. Careful planning is therefore needed to optimize the design of nature-inclusive structures.

Within this context, this PAS has been created to establish, and uphold, holistic, good practice for nature-inclusive marine structures, throughout their life cycle in the context of marine construction projects. This PAS is laid out following the typical life cycle of a marine structure, through effective planning, design, implementation, monitoring and decommissioning, aiming to contribute effectively to the global effort to renew and protect our planet's biodiversity and climate.

This PAS aims to have a good effect on the world by promoting the use of nature-inclusive marine structures, compared to conventional non-nature-inclusive alternatives. It does not support greenwashing or the misuse of these structures to justify destructive projects. The intention is to ameliorate the impacts of ongoing “ocean sprawl”, not to intensify it.

Using nature-inclusive structures does not guarantee a net positive effect on the marine environment, but it is expected to be more beneficial than using non-nature-inclusive structures. Environmental risks and impacts are inherently associated with deploying structures in marine environments. Therefore, this PAS provides guidance on nature-inclusive design and planning to help to address these risks and impacts.

Nature-inclusive structures can incorporate a variety of measures to mitigate the environmental impacts of marine construction projects and whilst this PAS is not intended to comprehensively guide users on impact mitigation, it does include provisions to prevent the misrepresentation of nature-inclusive structures and to ensure that nature-inclusive design is considered alongside all feasible impact mitigation measures.

Commented [MR1]: Our members would welcome clarity on linkages to offshore wind developments, the consultation provides limited detail on how it relates to specific developments (e.g. offshore windfarms).

Commented [MR2]: We recommend consideration should be given to minimise the risk of attracting Invasive Non-Native Species (INNS).

Commented [MR3]: where

Commented [MR4]: Monitoring and Evaluation - SR members' question:
1. Who will be responsible for carrying out and funding the monitoring?
2. Will this be the responsibility of the developer or Local Planning Authorities/Government?
3. Will necessary funding be made available to train the workforce to carry out monitoring?
4. Who will be accountable if nature-inclusive marine structures have not been successful?
5. Without the use of a marine net gain metric, what is considered a success?

Therefore, this PAS does not state whether a particular marine construction project is objectively good or bad for the environment. It does, however, state whether marine structures are nature-inclusive and whether they incorporate nature-inclusive design, in accordance with the definitions and provisions provided herein.

Users are encouraged to approach this PAS pragmatically. While the PAS provides a framework for decision-making, users rely on their own judgment and advice from competent professionals in relevant technical fields. The PAS serves as a guide, but it is crucial for users to apply their decision-making faculties in context and exercise pragmatism in the level of effort, documentation, and rigour applied to works governed by this PAS, with effort being proportional to the project's scale and scope. For smaller projects, a lower level of time and effort in analyses such as life cycle assessment, options evaluation, and ecological monitoring might be acceptable, as long as it aligns with the project's scale and potential impacts. In contrast, larger projects are expected to allocate sufficient resources to conduct thorough formal analyses. This ensures that the responsibilities associated with producing nature-inclusive structures at scale are adequately met. By applying proportionality, the PAS remains a flexible document applicable to all structures and projects.

1 Scope

This PAS gives recommendations on how to specify the design of marine nature-inclusive structures in a way that positively integrates them with the marine environment. It also provides recommendations on how to plan for and implement such structures in a sustainable, practical manner; how to assess the ecological efficacy of nature-inclusive structures and how to decommission them responsibly.

This PAS covers guidance relating to the core principles of nature-inclusive design, integration of nature-inclusive design with sustainable planning practices, such as biodiversity net gain (BNG) and other emerging practices including marine net gain (MNG), net positive impact (NPI), natural capital approaches, etc. It also covers guidance relating to the integration of nature-inclusive structures with the restoration of biogenic habitats by augmenting structures with habitat-forming species.

This PAS is applicable to any structure or set of structures that will be placed in marine environments during marine construction projects (hereafter referred to as “projects”). It is also applicable to the modification or enhancement of existing man-made structures already located in the marine environment.

This PAS is intended for use by anyone procuring, using, designing, or developing marine structures. It is intended for use by:

a) design and pre-construction professionals specifying nature-inclusive designs, selecting existing designs and developing new designs;

b) developers and lease holders procuring nature-inclusive structures or nature-inclusive design services;

c) project managers and engineers integrating nature-inclusive designs or nature-inclusive structures into projects; and

d) ecologists aiming to improve post-build biodiversity metrics of projects with nature-inclusive design.

This PAS is also of interest to marine licensing authorities and regulators responsible for the permitting of projects, aiming to verify eco-centric and sustainable development practices.

This PAS does not cover:

1) technical engineering criteria or tests, such as structural design, lifting methodologies or maintenance inspections;

2) quality control measures for the production of structures;

3) deployment methods and logistics processes;

NOTE 1 Users are advised to follow existing specialist advice, industry standards, guidance notes and requisite legislation for these topics. For example, BS EN ISO 9001 provides guidance on the establishment of effective quality management systems.

4) recommendations for specific nature-inclusive design features to suit different locations;

NOTE 2 For design recommendations, users are advised to seek up to date guidance documents, especially those that synthesize ecological engineering theory and peer reviewed research, for example, Evans, 2021 [3]; Glarou et al., 2020 [4]; Lengkeek et al., 2017 [5].

5) specific guidance on the comprehensive assessment and mitigation of environmental impacts across a project;

NOTE 3 Environmental impacts and appropriate mitigation has to be assessed on a project by project basis.

6) guidance on whether the use of marine structures is appropriate to a given area or on the criteria for acceptance of a project during licensing processes; or

7) comprehensive guidance on the development and management of nature-based solutions.

NOTE 4 Nature-inclusive design can be used as a tool within nature-based solutions, in which case users are advised to integrate nature-inclusive structures with wider best practice for the management of nature-based solutions, for example, Bridges et al., 2021 [6]; IUCN, 2020 [7]).

NOTE 5 It is important to provide clarity on the crossovers and distinctions between these concepts: nature-based solutions and nature-inclusive design. Both nature-based solutions and nature-inclusive design aim to enhance biodiversity or ecosystem services while addressing societal needs, with a strong emphasis on sustainability and the integration of natural processes. Nature-inclusive design can be seen as a specific approach or tool within the broader framework of nature-based solutions. However, there are notable differences: nature-based solutions have a broader scope, addressing a wide range of societal challenges through ecosystem-based approaches, often at larger scales such as landscapes or regions. In contrast, nature-inclusive design is more focused on the built environment and infrastructure, dealing with the integration of natural elements within man-made structures. Additionally, nature-inclusive design is typically implemented at a more granular level, such as individual buildings or construction areas, whereas nature-based solutions can span larger geographical areas and encompass more diverse applications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions, or limits the application, of this document[1]. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 8683:2021**,** *Process for designing and implementing Biodiversity Net Gain* **–** *Specification*

BS EN ISO 14040, *Environmental management – Life cycle assessment – Principles and framework*

BS EN ISO 14044, *Environmental management – Life cycle assessment – Requirements and guidelines*

BSI Flex 350 v1, *Alternative binder systems for lower carbon concrete – Code of Practice*

[1] Documents that are referred to solely in an informative manner are listed in the Bibliography.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purpose of this PAS, the following terms and definitions apply.

3.1.1 adaptive management
approach to natural resource management that enables effective action within complex socio-ecological systems by considering the consequences of actions and improving future management based on iterative learning

[SOURCE: Webb et al. 2017 [8]]

3.1.2 biodiversity net gain (BNG)
specific, quantifiable outcome of project activities that deliver demonstrable benefits for biodiversity compared to the baseline situation

[SOURCE: BS 8683:2021, **3.1.6**]

3.1.3 biogenic
produced by living organisms

3.1.4 biotope
combination of an abiotic habitat and its associated community of species

NOTE 1 Biotope is used here in the marine context.

NOTE 2 This term is used to describe spatially discrete ecological units in marine and aquatic systems.

3.1.5 biomass
total quantity or weight of organisms in a given area or volume

3.1.6 blue economy
economic system or sector that seeks to conserve marine and freshwater environments while using them in a sustainable way to develop economic growth and produce resources such as energy and food

3.1.7 competent person
person who can demonstrate they have acquired through training, qualifications or experience, or a combination of these, the knowledge and skills enabling that person to perform a specified task

[SOURCE: BS 8683:2021, **3.1.7**]

3.1.8 ecological engineering
design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both

[SOURCE: Mitsch, W.J., 2012 [9]]

3.1.9 ecosystem
biological community of interacting organisms and their physical environment

3.1.10 ecosystem service
benefits people obtain from ecosystems

NOTE These include products obtained from ecosystems (e.g. freshwater, food, fuel, genetic resources, natural medicines, etc.); benefits obtained from the regulation of ecosystem processes (e.g. water erosion, waste, climate and natural hazards); cultural services (e.g., cultural diversity, educational values, social relations, heritage, etc.) and services that are necessary for the production of other ecosystem services (e.g. primary production, nutrient cycling, and water cycling).

[SOURCE: Millenium Ecosystem Assessment, 2005 [10]]

3.1.11 endobenthos
organisms that live within the substrates of aquatic environments, such as the sediments of oceans, rivers, lakes, and seas

NOTE 1 This group encompasses a variety of life forms, including animals, microorganisms, and other organisms that burrow into or reside within the sediment, rather than on its surface.

NOTE 2 Synonymous with "infauna"

3.1.12 epibenthos
community of organisms that live on the surface of a substrate, especially in aquatic environments

NOTE This term encompasses all organisms, including animals, plants, algae, bacteria, and fungi that live on the surface of substrates.

NOTE Synonymous with "epifauna" and "epiflora".

3.1.13 environmental product declaration
claim which indicates the environmental aspects of a product or service, providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information

[SOURCE: BS EN ISO 14025:2010, **3.1**, **3.2**]

3.1.14 greenwash
mislead (the public) or counter (public or media concerns) by falsely representing a person, company, product, etc., as being environmentally responsible

3.1.15 habitat
natural home or environment of an animal, plant, or other organism

3.1.16 indicator species
organisms whose presence, absence, or abundance reflects a specific environmental condition or the health of an ecosystem, serving as a measure of the environmental conditions that are suitable for a wider group of species

3.1.17 integrated green grey infrastructure
combination of green infrastructure with grey infrastructure, combined in a synergistic manner to improve the environmental effects of grey infrastructure engineering

NOTE 1 In this PAS, the concept of integrated green grey infrastructure is considered as synonymous with the concept of nature-inclusive grey infrastructure, which has been designed to incorporate natural processes and features into built environments to enhance biodiversity, resilience, and ecological health.

NOTE2 "Green" infrastructure refers to natural or living environments that act as infrastructure for human purposes such as flood defence, "grey" infrastructure refers to artificial, anthropogenic infrastructure.

3.1.18 irreplaceable habitat
habitat that cannot be recreated within a specified time frame because it would be technically very difficult or impossible to recreate taking into account its age, uniqueness, species diversity, rarity and environmental or historical context

NOTE In the context of planning in England irreplaceable habitat has a specific legal definition for more information see: https://www.gov.uk/guidance/irreplaceable-habitats.

[SOURCE: BS 8683:2021, **3.1.8**, modified – changed 'their' to 'its']

3.1.19 keystone species
species that has a disproportionately large impact on ecosystem function and diversity relative to its abundance, playing a critical role in maintaining the structure of an ecological community and influencing the types and numbers of other species in the habitat

3.1.20 life cycle assessment (LCA)
compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle

[SOURCE: BS EN ISO 14044:2006+A2:2020, **3.2**]

3.1.21 lower carbon concrete
concrete with an embodied CO_2 equivalent (kg CO_2e/m^3) lower than 80% of the concretes in use across the market for the relevant strength class

[SOURCE: BSI Flex 350 v1.0:2023-10, **3.1.8**]

3.1.22 marine
all ocean and coastal waters, including intertidal zones and saltwater marshes, as well as adjacent coastal and riparian land areas, and extending, in the case of watercourses, up to the freshwater limit

[SOURCE: United Nations, 1992 [11]]

3.1.23 marine construction projects
planning, design, and execution of construction activities in marine environments (see **3.1.22**)

NOTE These projects typically involve the creation, maintenance, modification or decommissioning of structures and infrastructure to support various activities such as transportation, energy production, and coastal protection.

3.1.24 marine structure
physical construction designed and placed in a marine environment for a specific purpose, as part of human development activities

NOTE 1 This includes a wide range of built forms, from individual components to complex systems, intended for various uses such as coastal protection, habitat creation, resource exploitation, or recreational facilities. For example, both a single block intended for scour protection at an offshore wind farm and an entire scour protection berm made of multiple blocks are both considered here as "structures".

NOTE 2 In this PAS, designed marine structures are simply referred to as marine structures.

3.1.25 mature community
community that having undergone succession, is a stable and established ecosystem characterized by a complex structure, biodiversity, and interactions among organisms

3.1.26 microhabitat
small, specific area within a larger habitat that differs in environmental conditions from the surrounding area, offering unique living conditions for certain species

NOTE These variations can be due to factors like moisture levels, light availability, sediment composition, temperature, or shelter, creating a specialized environment that supports a distinct community of organisms which might not thrive in the broader habitat.

3.1.27 mitigation hierarchy
hierarchical sequence of actions to anticipate and avoid impacts on biodiversity or ecosystem service; and, where avoidance is not possible, minimize; where impacts occur, restore; and finally where significant residual impacts remain offset

[SOURCE: BS 8683:2021, **3.1.9**]

3.1.28 nature-based solutions
actions to protect, conserve, restore, sustainably use, and manage natural or modified terrestrial, freshwater, coastal, and marine ecosystems, which address social, economic, and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience, and biodiversity benefits

[SOURCE: United Nations Environment Programme, 2022 [12]]

NOTE It is important to provide clarity on the crossovers and distinctions between these concepts: nature-based solutions and nature-inclusive design. Both nature-based solutions and nature-inclusive design aim to enhance biodiversity or ecosystem services while addressing societal needs, with a strong emphasis on sustainability and the integration of natural processes. Nature-inclusive design can be seen as a specific approach or tool within the broader framework of nature-based solutions. However, there are notable differences: nature-based solutions have a broader scope, addressing a wide range of societal challenges through ecosystem-based approaches, often at larger scales such as landscapes or regions. In contrast, nature-inclusive design is more focused on the built environment and infrastructure, dealing with the integration of natural elements within man-made structures. Additionally, nature-inclusive design is typically implemented at a more granular level, such as individual buildings or construction areas, whereas nature-based solutions can span larger geographical areas and encompass more diverse applications.

3.1.29 multi-criteria decision analysis (MCDA)
approach that involves evaluating and comparing different alternatives or options against a set of predefined criteria or factors that are important for the decision-making process

NOTE MCDA is widely used in various fields to assist in making well-informed and balanced decisions when faced with complex situations involving multiple competing objectives or criteria.

3.1.30 nature-inclusive design
design targeted at the integration of ecosystems, or specific habitats and species, with man-made architecture and infrastructure, via the intentional incorporation of habitat features, and backed by scientific evidence

NOTE Alternatively, also referring to the scientific approach of producing such a design.

Commented [MR5]: The definition seems to miss the objective of NID. This is key as some design choices are nature-inclusive but are not delivered through the incorporation of habitat features.

See CEMNID report definition which is worded differently:

Measures 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.

https://www.offshorewindscotland.org.uk/media/3xwecwpc/cemnid-nid-literature-review.pdf

3.1.31 nature-inclusive structure
man-made structure with a nature-inclusive design that has a documented consideration of ecosystems and environmental impact mitigation throughout its life cycle; during planning, design, implementation, monitoring and decommissioning

NOTE In the case of composite structures, the entire structure might be nature-inclusive or component structures might be nature-inclusive, for example, an entire nature-inclusive breakwater, or a breakwater with nature-inclusive armour units, could be developed. The degree of separation lies in the scope of nature-inclusive design; and ecosystem and environmental impact consideration/ mitigation.

3.1.32 nature positive
halting and reversing the loss of nature measured from its current status, reducing future negative impacts alongside restoring and renewing nature, to put both living and non-living nature measurably on the path to recovery

[SOURCE: IUCN 2022, modified from term "nature-positive future" [13]].

3.1.33 nekton
actively swimming aquatic organisms that can move independently of water currents

3.1.34 ocean sprawl
proliferation of engineered artificial structures in coastal and offshore marine environments.

NOTE These include ship hulls; infrastructure associated with land reclamation and urbanization (e.g., seawalls, bridges, floating docks); fisheries (artificial reefs, aquaculture installations); coastal defence structures (e.g., breakwaters, groynes); resource extraction (oil and gas rigs, renewable energy devices); and shipwrecks.

[SOURCE: Firth, 2021 [14]]

3.1.35 optioneering
in-depth consideration of various alternatives to find the best or preferred option

[SOURCE: Wiktionary https://en.wiktionary.org/wiki/optioneering]

3.1.36 outplant
transplant from a nursery bed, greenhouse, or other location to an outside area

NOTE In this PAS, the term is used to refer to the outplanting of epibenthic fauna and flora such as coral, oyster or seaweed species.

[SOURCE: Mirriam-webster, https://www.merriam-webster.com/dictionary/outplant - modified]

3.1.37 plankton
organisms that drift or float in water currents and have little to no ability to swim against these currents

3.1.38 pseudo-replication
the use of inferential statistics to test for treatment effects with data from experiments where either treatments are not replicated (though samples may be) or replicates are not statistically independent.

[SOURCE: Hurlbert, S.H., 1984 [15]]

3.1.39 seascape
interconnected system of marine and coastal environments, encompassing both physical and biological components

NOTE 1 It includes not only the water bodies but also the associated features such as coastlines, estuaries, habitats including reefs and sea mounts, and ocean floors. The seascape concept emphasizes the dynamic and holistic nature of marine ecosystems, recognizing the interplay between different marine habitats and the organisms that inhabit them, as well as the influence of human activities and natural processes.

NOTE 2 The term in this PAS is used in reference to seascape ecology, whereby the wider seascape and interconnectedness of habitats is considered, not the visual seascape to human viewers.

3.1.40 species
group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding. The species is the principal natural taxonomic unit, ranking below a genus and denoted by a Latin binomial, e.g. *Homo sapiens*

3.1.41 substrate
material making up the base upon which an organism lives or to which it is attached

NOTE The substrate is not necessarily the seafloor; it can be any biotic or abiotic material. For example, encrusting algae that live on a rock can be substrate for another animal that lives on top of the algae.

[SOURCE: https://www.coastalwiki.org/wiki/Definitions_of_marine_ecological_terms#S]

3.1.42 type 1 error
incorrect rejection of a true null hypothesis, often referred to as a "false positive", where an effect or difference is concluded to exist when it does not

3.1.43 type 2 error
failure to reject a false null hypothesis, known as a "false negative," where no effect or difference is concluded to exist when, in fact, it does

3.1.44 umbrella species
species whose conservation provides protection for a wide range of other species that share its habitat

NOTE In marine ecology and nature-inclusive design, protecting these species indirectly conserves the larger ecological community and the natural habitat they depend on. Umbrella species are selected for conservation efforts because their habitat requirements are broad and encompassing, ensuring that protecting these species and their habitats also protects a wide range of other species that share the same environment.

3.2 Abbreviated terms

BACI	before after control impact
BAG	before after gradient
BNG	biodiversity net gain
BPEO	best practicable environmental option
CA	comparative assessment
CIEEM	Chartered Institute of Ecology and Environmental Management
EcIA	ecological impact assessment
EIA	environmental impact assessment
GI	green infrastructure
IGGI	integrated green grey infrastructure
LCA	life cycle assessment or life cycle analysis
PEA	preliminary ecological appraisal
MCDA	multi-criteria decision analysis
NEBA	net environmental benefit analysis
NNS	non-native species
RAMS	risk assessment method statements

4 Planning of nature-inclusive structures

*COMMENTARY ON CLAUSE **4***

This clause is aimed at providing guidance on how to effectively integrate nature-inclusive design of marine structures into sustainable project planning, it is not aimed at providing instructions on how to perform specific planning processes like EIA or the submission of licensing applications but how nature-inclusive design can best be integrated with these existing processes. The specific execution of many of the provisions in this clause are dependent on the policies, regulations and licensing requirements of the particular project. There is an assumption there will be a statutory authority which a project consortium can refer to for permission within a project.

4.1 General guidance on planning integration

Nature-inclusive design of marine structures should be incorporated as an additional element within existing good practice for sustainable marine development.

Nature-inclusive design practitioners should verify projects follow regional, national and international good practice and policies for sustainable development in the marine environment.

NOTE 1 For example, in the UK in coastal marine environments down to the mean low water mark, practitioners could integrate nature-inclusive design with BNG planning practices following the specification of BS 8683:2021, principles of BNG [16] and the practical guide for good practice [17].

NOTE 2 BNG planning is an example of good planning practice that integrates well with nature-inclusive design practices as it emphasizes early assessment of environmental impacts, consideration of impacts during design, qualitative and quantitative biodiversity baselines and comprehensive stakeholder engagement.

NOTE 3 BNG is a specific example of planning practice within a wider field of emerging international "nature positive" planning approaches. Users are advised to stay abreast of contemporary terminology and planning practices in this continually evolving field.

Those planning the use of nature-inclusive designs should aim for streamlined integration in to planning practice, aiming for cost efficiency.

Commented [MR6]: For Offshore Wind projects due to the advances in Offshore Wind technology a Rochdale Envelope approach is applied at the Environmental Impact Assessment (EIA) stage, with the final design and supply chain confirmed closer to the point of final investment decision.

Whilst the principles of Nature Inclusive Design could be proposed at EIA/planning stage, the design for this could not be confirmed until final design and procurement is undertaken.

Risk management processes should be implemented from the first stage of design so that risks can be mitigated progressively throughout the design process.

Effort should be proportional to the project's scale and scope. For smaller projects, a lower level of time and effort in analyses such as life cycle assessment, options evaluation, and ecological monitoring might be acceptable, as long as it aligns with the project's scale and potential impacts. In contrast, larger projects should allocate sufficient resources to conduct thorough formal analyses.

4.2 When and how to integrate nature-inclusive design

The use of nature-inclusive designs should be considered early in a project's planning, as a potential method of mitigating environmental impacts of marine structures and of improving their ecological performance. Projects incorporating nature-inclusive design of marine structures should consider the factors for selecting goals and developing designs as soon as the decision to incorporate nature-inclusive design is made (see **5.1** and **5.2**).

Environmental impacts of a project should be considered early, to inform the use of nature-inclusive design and to inform the nature-inclusive design process where it is to be used.

NOTE 1 For example, practitioners may perform preliminary ecological appraisals (PEA) early in a project, in accordance with guidance by CIEEM [18], as a lower cost informative tool compared to full Environmental Impact Assessments (EIA) and Ecological Impact Assessments (EcIA) to be subsequently produced.

Rigorous impact assessments should be performed, EIAs should be performed and detailed EcIAs should be performed as part of EIAs.

The use of nature-inclusive designs should be planned in addition to all feasible impact mitigation measures, in accordance with the mitigation hierarchy and relevant location-specific best practice for the mitigation of marine environmental impacts.

NOTE 2 For example, appropriate site selection is an effective mitigation measure that can be considered, especially to avoid impacting protected habitat features in marine protected areas. A specific example could be avoiding construction over existing coral reef patches as an effective mitigation measure, combined with nature-inclusive design that emulates the structural shapes of bedrock or corals. This approach creates artificial habitats that integrate with the local coral reef ecosystem while minimizing the impact on natural reefs.

NOTE 3 Users are also advised to refer to local, national and international planning policies relevant to the project location.

NOTE 4 Impacts to soft sediment habitats is an important category of environmental impacts because structures can change the nature of these habitats drastically, see Heery et. Al [19] for a list of the potential environmental impacts to soft sediment habitats.

As part of effective planning processes, project developers should engage with stakeholders, including local communities, ecologists, urban planners, and regulatory bodies – including statutory nature conservation bodies – as applicable from the outset. The feasible incorporation of nature-inclusive structures should be incorporated into stakeholder engagement information. The opinion of stakeholders regarding the suitability of designs should be gathered and recorded.

Nature-inclusion goals (see **5.2.3**) should be reviewed and accepted by the appropriate statutory authority during the project design phase. Provisional ecological monitoring plans should be developed following acceptance of the nature-inclusion goals (see Clause **7**). The scale and extent of ecological monitoring required should be agreed within the project consortium including the appropriate statutory authority; and should be considered in light of project specific factors including but not limited to the scale of structures spatially and the level of certainty of the efficacy of nature-inclusive design features.

NOTE 5 For example, experimental design features require a greater focus in ecological monitoring programs than more established designs with greater evidential support in scientific research.

NOTE 6 Engaging with a wide array of stakeholders in a collaborative manner helps nature-inclusive design practice to harmonize with local ecological, social and regulatory contexts.

Commented [MR7]: SR members note that ideally this is the case but there are opportunities to deploy Nature-Inclusive Design (NID) structures at operational sites, for example where additional scour or cable protection is needed within an Offshore Renewable Energy (ORE) site.

Whilst the majority of this document can be applied to such scenarios, in some cases, such as the options for monitoring design may be more limited than in the case of a completely new development.

Commented [MR8]: As above, the final design of an Offshore Wind project typically takes place after EIA and planning consent is awarded.

Our members question whether this would mean additional EIA, specific to the NID proposed would be required?

Commented [MR9]: SR members question what role urban planners have?

Information gathered during stakeholder engagement should be made available to those setting goals for and developing nature-inclusive designs.

NOTE 7 Practitioners can refer to Technical NOTE T4 in A practical guide *[17] for guidance on engaging stakeholders on BNG throughout a project life cycle.*

Project planners should adopt an interdisciplinary approach by involving architects, ecologists, engineers, and other relevant professionals as required to verify nature-inclusive designs are holistically and appropriately integrated into the project.

Nature-inclusive designs of marine structures and implementation strategies should be defined and selected by the consent application stage, as changes post-approval could lead to complications or the need for additional permissions.

Commented [MR10]: SR members agree this is not always possible. Due to the time lag between consent application and construction of large-scale projects, such as ORE, flexibility is required at the application stage with the final selection of specific design of specific design details and layout not confirmed until nearer to the time of construction.

Applications should therefore include NID options/principles/goals allowing the final selection of structures to be made closer to construction allowing the opportunity to select from the most up-to-date options the design which best suits the project as executed.

Refer to National Policy Statements and NSIP Advice Note Nite: Rochdale Envelope.

4.3 Integration with project planning documentation

Projects should clearly define which structures are intentionally nature-inclusive.

NOTE 1 Having a clear definition of which structures in a project are nature-inclusive and which are not can help with clarity in documentation, design, implementation and subsequent monitoring and decommissioning efforts.

Nature-inclusive design details, documentation and drawings, including the rationale for design selection and goals of nature-inclusive designs (see **5.1** and **5.3**) should be incorporated into project documentation.

Nature-inclusive designs of structures, where used, should be described in detail in applications to licensing authorities.

Nature-inclusive designs of structures and the rationale for their designs should be incorporated in EIAs, EcIAs, Habitats Regulations Assessments/Appraisals (HRAs) and other supporting documentation for the project.

When documenting details of mitigation measures to avoid, minimize, restore or offset adverse impacts on the marine environment, planners should include consideration of the nature-inclusive design of structures, explaining if and how these designs help in mitigating predicted negative impacts.

Nature-inclusive design documentation should be made available for future reference during monitoring, management, maintenance and decommissioning of the structure.

In applicable environments, where a biodiversity gain plan is to be completed, then the nature-inclusive design details should be incorporated.

NOTE 2 A template for biodiversity gain plans in the UK can be found at the following link: Biodiversity gain plan - GOV.UK (www.gov.uk)

Nature-inclusive design of marine structures should be considered as a method for improving biodiversity metrics, compared to structures without nature-inclusive design.

NOTE 3 For example, The Statutory Biodiversity Metric of the UK government [20], applicable to structures placed in the intertidal environment, at the time of publication includes higher scores of distinctiveness for Integrated Green Grey Infrastructure (IGGI) compared to other intertidal artificial structures and effective nature-inclusive design might improve the resulting condition of such novel habitats.

Proposals for monitoring the impacts of the project should include how the effectiveness of the nature-inclusive designs is to be assessed over time (see **7.5**). This should include how any unforeseen negative effects are to be managed. A commitment to the ecological monitoring should be made and documented during the design phase of a project.

In addition to conventional planning documents including EIAs, documents specific to nature-inclusive marine structures should therefore include at least:

a) nature-inclusive design documentation including all the recommendations in the design procedure in **5.2**, justification of material selection (see **5.5**) and with technical drawings appended (see **5.3**);

b) life cycle assessment(s) (see **5.4**);

c) rationale for option selection during optioneering (see **4.6**);

d) an augmentation plan – if augmenting with habitat-forming species is planned (see **6.2**); and

e) an ecological monitoring plan (see Clause **7**).

The level of detail, amount of content and effort applied during preparation should meet the recommendations of the clauses detailed and should be proportionate to the requirements of the project.

NOTE 4 The intention is for the planning and documentation recommendations to provide a holistic accountability for nature-inclusive marine structures, not to make nature-inclusive structures unfeasible for projects without large budgets.

4.4 Preventing the misrepresentation of nature-inclusive design

Nature-inclusive design should not be used as a tool for increasing the degradation of biodiversity, via greenwashing of destructive projects. Nature-inclusive design should not be used as a means of justifying projects that cause net loss or damage to species of conservation priority or irreplaceable habitats.

NOTE 1 Annex A provides a checklist of good practice to facilitate accountability and quality assurance of nature-inclusion.

NOTE 2 Two primary means by which nature-inclusive design or claims of nature-inclusive design can be used for the greenwashing of a construction project are as a "fig-leaf" covering up environmental damage with disproportionately small positive effects, in the absence of information regarding impacts; or as a "trojan horse" deliberately causing harm under the guise of environmental benefits. See Firth et al. [21], [22] for further details. An example of a fig-leaf would be where the purported environmental benefits of a structure as an artificial reef are used to cover up the damage that construction of the structure caused to underlying baseline ecosystems. An example of a trojan horse would be where the creation of a supposedly nature-inclusive structure is used as an excuse for the irresponsible dumping of waste at sea, some historic examples might include the creation of waste tyre artificial reefs.

The use of nature-inclusive design should not be communicated in the absence of environmental impact information for a project. Nature-inclusive design should not be used to create the perception of net environmental benefits without consideration of the environmental impacts of a project by a competent person and balanced communication of these impacts.

Commented [MR11]: Again, our members highlight timing is the barrier to this.

The planning process should be transparent and include opportunities for public participation.

Long-term ecological monitoring should be implemented to track the outcomes of nature-inclusive design.

NOTE 3 If the goals of nature-inclusive design are not met, adaptive management measures may be taken.

NOTE 4 Adaptive management measures include habitat restoration and enhancement practices such as replanting vegetation, modifying structures, adjusting operational practices, or re-evaluating goals, success criteria and monitoring strategies.

The results of ecological monitoring should be publicized, along with lessons learnt.

NOTE 5 The importance of communicating the results of ecological monitoring is exemplified by examples of greenwashing whereby a solution is bound for failure from the outset. For example, a project could integrate a nature-inclusive design with the planting of mangrove trees in a way that is bound for failure whereby the mangroves will die before growing into an effective habitat. The project could communicate the success and eco-friendliness of their mangrove planting with no follow-up monitoring and so no true communication of the efficacy *of the nature-inclusive design. Furthermore, a nefarious practitioner could continue to use the site for mangrove planting in perpetuity despite no long-term effective mangrove habitat creation.*

NOTE 6 Results could be disseminated and incorporated into education, training, guidelines and resources to aid the continuous improvement of practice.

4.5 Engaging with stakeholders regarding nature-inclusive design

Practitioners using or developing nature-inclusive marine structures should consult with members of key stakeholder groups with an interest in the project area, to inform stakeholders of the projects' design, planning, monitoring, decommissioning and the key risks associated with the structures. Practitioners should approach members of such groups with the aim of discerning the following aspects:

a) the importance of the site to them and why it is important;

NOTE 1 For example, commercial reasons, or recreational value.

b) its historical value (if any);

c) the species to be considered in the nature-inclusive design; and

d) any history of habitat alteration at the site.

NOTE 2 Key stakeholder groups to consider include blue economy members such as fishers, aquaculturists and tourism operators, recreational users, dive groups, public, statutory bodies and community groups.

4.6 Optioneering

*COMMENTARY ON **4.6***

Optioneering in the context of nature-inclusive designs, including for marine structures, refers to the process of exploring and evaluating different design options to achieve the best possible outcomes in terms of biodiversity enhancement, impact mitigation, functionality, cost-effectiveness, and stakeholder acceptance. Optioneering is about identifying and assessing various alternatives to find the most suitable solution that aligns with the project's ecological, social, and economic objectives.

Optioneering is a process that may be applied to a project of any scale utilizing nature-inclusive structures. Those considering the incorporation of nature-inclusive structures in marine development projects should take into account how different options perform in terms of:

a) environmental aspects including impacts and benefits via nature-inclusive design;

b) engineering efficacy;

c) costs;

d) social aspects, including stakeholder opinion, local regulatory environment, potential ecosystem services generated by nature-inclusive structures and any additional benefits; and

e) risks.

Commented [MR12]: Our members presume this includes safety considerations.

When considering these factors, practitioners should verify that the opinion of competent persons in the relative field of each factor has been taken into account.

Consideration of environmental effects should include the integration of options with the local marine ecosystem, including the predicted efficacy of nature-inclusive design features in mitigating negative impacts and enhancing beneficial effects.

Nature-inclusive design details should be assessed against the stated goals. The scientific rigour of the rationale for design and the appropriateness of the goals should be checked by a competent person.

Environmental effects of the project options should be considered both to the ecosystem in the region and to the wider environment across the whole life cycle of options.

NOTE 1 Standardized methods and principles can be utilized to improve the accuracy of impact estimates.

Preliminary EIAs of each option and preliminary LCAs should inform decision-making and risk assessments. Effective and comprehensive assessment of potential impacts of the structures should be incorporated, without compromising on cost and time to perform the initial assessment.

NOTE 2 Industry experience and technical consultation can be beneficial at this stage. For example, standardized methods for PEAs, EcIAs and EIAs can be used to assess the direct environmental impacts of structural placement in the marine environment (e.g. CIEEM, 2018 [23], CIEEM, 2017 [24]). LCA methods can be used to quantify wider environmental impacts of the project's completion.

Risk assessment should be performed to assess environmental, health and safety and engineering risks for different scenarios. Experimental nature-inclusive design features should be factored in to risks under the umbrella of nature-inclusive design goals not being successfully achieved.

Practitioners can use MCDA as a tool to compare and integrate the competing decision-making factors between different scenarios.

NOTE 3 Annex B provides an example process for completing MCDA during nature-inclusive design optioneering.

Those using MCDA methods should check that factors are scored accurately. By default, weighting of scores should be equal between ecological, engineering, social, cost and risk type scoring criteria.

NOTE 4 Alternate weighting may be applied between scoring factors in MCDA, as an exploratory tool or to suit particular requirements of a project.

If different weighting is applied between factors this should be clearly documented and justified in optioneering documentation.

NOTE 5 The process of scoring criteria in MCDA during optioneering can be quantitative and qualitative. The approach depends on the nature of the criteria and the availability of data.

Where MCDA methods are used, results should be interpretated as informative aids, using the scores as guidelines to inform decision-making, rather than as absolute determinants.

NOTE 6 Using MCDA as an informative tool rather than an absolute determinant allows more flexibility in decision making which is essential in complex projects like those with marine engineered structures. Having such flexibility accounts for a more holistic nuanced view, the dynamic nature of projects, subjectivity in scoring of qualitative factors and allows for combining elements from different options in a complementary strategy.

After considering the required factors and selecting options, transparent communication should be maintained by clearly communicating why a particular option was chosen, especially if it was not the highest scoring option in MCDA. Detailed records of the decision-making process should be maintained including reasons for deviating from score-based recommendations if this has occurred. Decisions should be regularly reviewed against project progress and evolving conditions.

5 Nature-inclusive design of marine structures

*COMMENTARY ON CLAUSE **5***

The procedure described in this clause is equally applicable to those specifying nature-inclusive designs for a project, those selecting existing nature-inclusive designs for use in a project or those creating new nature-inclusive designs, whether for a specific project or for generalist product development.

5.1 Principles of nature-inclusive design

The development of nature-inclusively designed marine structures should follow these principles, as shown in Figure 1:

a) harmony: designs should be specified and developed with the local environment, biotope, wider ecological seascape, spatial planning and human community in mind;

b) optimization: features beneficial to local biodiversity should be maximized and features negatively impactful to local biodiversity should be minimized;

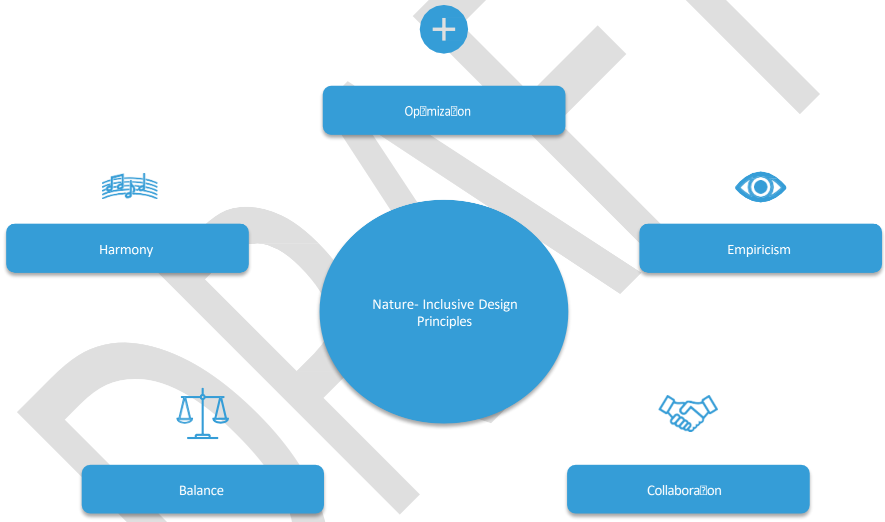
NOTE For example, a practitioner of nature-inclusive design might choose to maximize refugia for juvenile fishes and to minimize loss of natural substrates.

c) empiricism: observation and experimentation should be utilized to develop and test designs that work towards defined goals, with measurable success criteria. Historic scientific and/or empirical evidence should be used and built upon;

d) collaboration: inter-disciplinary collaboration is fundamental to achieving effective nature-inclusive design; and

e) balance: the seemingly competing interests in the design should be balanced, especially engineering and ecological requirements. Designs should fulfil the engineering requirements of the structures. The ease and cost of implementation of the designs should be considered while maintaining practicality and remaining ambitious for positive ecological effects. The potential benefits of nature-inclusive design should be considered in balance with the artificial alteration of habitats and negative impacts of projects.

Figure 1 – Principles of nature-inclusive design



5.2 Design development procedure

5.2.1 General

NOTE 1 This procedure may be carried out iteratively, revisiting previous steps as required.

NOTE 2 Goals might be revisited as the practicality of achieving them becomes clearer throughout the design process.

The development procedure should be performed:

a) concurrently with other activities in the preparation and design phases of projects;

b) collaboratively, facilitating information sharing and interaction with other work packages during project planning such as optioneering, cost estimation, life cycle assessment and technical design;

c) by compiling supporting information for goal setting (see **5.2.2**) and setting nature-inclusion goals (see **5.2.3**) of the procedure first; and

Commented [MR13]: This is dependant on the NID measure being proposed, there may be a limited evidence base to build upon.

Commented [MR14]: This is helpful, particularly in regard to dynamic cables required for floating offshore wind, where marine growth would add weight and impact loading - conventional design approaches would therefore seek to minimise marine growth.

Commented [MR15]: And safety

*NOTE 3 Subsequently, any of the steps within **5.2** may be performed or repeated in any order of the practitioners choosing, given the specific situation they find themselves in.*

d) by completing and documenting all steps of the procedure.

NOTE 4 The suggested order of procedure as given in Figure 2 follows a logical rational order but does not consider the particular complexities of projects. Users are advised to follow their judgement in approaching the order of activities during the development procedure.

Figure 2 – Nature-inclusive design development procedure

The recommended design development procedure should be as given in **5.2.2** to **5.2.10**.

WARNING. THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A PUBLISHED PAS.

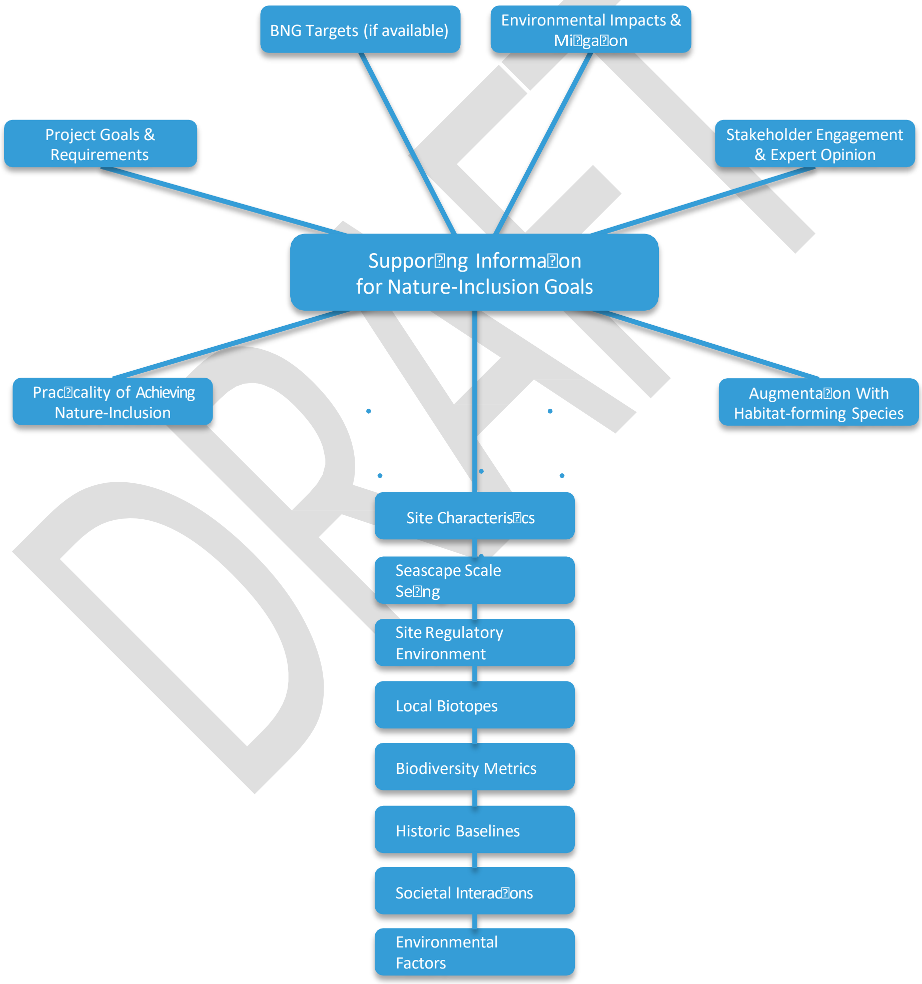
5.2.2 Compile supporting information for goal setting

Supporting information should be used as the rationale for the design, and utilized when creating nature-inclusion goals.

Users completing nature-inclusive design of marine structures should compile and utilize the information available. They should continue adding to the compiled information base as new information becomes available, as it develops during the project development process.

NOTE Information sources are available online, depending on the locality and the type of information in question. For example, in Europe, a broad-scale seabed habitat map is available, called the EU Sea Map, available through EMODnet at https://emodnet.ec.europa.eu/en/seabed-habitats#sbh-background.

Figure 3 – Supporting information for nature-inclusion goals



As shown in Figure 3, the information compiled and considered during goal setting should include:

a) project goals and the project requirements for marine structures, including the intended purpose of structures and design life;

NOTE 1 See BS 6349-1-1 for guidance on defining design working life for maritime works.

NOTE 2 This could include the primary purpose of a structure in a 'traditional' engineering context for example as a seawall for coastal defence, or in a nature-based solutions context for example the stabilisation and facilitation of mangrove forest restoration as part of long-term coastal management.

b) BNG targets and baseline if defined for the project as part of BNG planning, in accordance with the specifications of BS 8683;

c) environmental impacts, the mitigation hierarchy and the concept of like for like or better;

*NOTE 3 As noted in Clause **4**, environmental impacts are to be considered early in the project to afford proactive environmental management via nature-inclusive design. Early preliminary environmental impact assessments may be performed to save the cost of additional full EIAs. Shorter ecological appraisal or scoping could be performed or a more informal consideration of the likely environmental impacts.*

NOTE 4 See Heery et al. [19], Table 1, for a list of documented environmental impacts of marine structures on soft substrate habitats.

NOTE 5 Stakeholder engagement can supply input on the perceived, predicted environmental impacts of a development incorporating local and expert knowledge, especially that of the appropriate nature conservation statutory authority.

d) stakeholder engagement and expert opinion, including that of the appropriate statutory authority;

e) site characteristics, including:

1) seascape scale setting;

2) site regulatory environment;

NOTE 6 For example, marine plans and protected areas in the locality.

3) local biotopes;

4) biodiversity metrics baseline pre-development;

5) historic baselines;

6) societal interactions with the local environment including but not limited to exploitation of local natural resources by fisheries and aquaculture, recreational site usage, ecosystem services, public access and other additional benefits;

7) environmental factors including but not limited to water level, tidal range, water depth and exposure to waves and currents;

NOTE 7 Guidance for environmental survey methods relevant to the design of maritime works can be found in BS 6349-1-1.

NOTE 8 Nature-inclusive designs might also benefit long-term by a consideration of future environmental scenarios at the project location and goals can be focused toward increasing the resilience of ecosystems to future climate change pressures.

f) practicality of achieving the goals; and

g) the potential for augmentation of native habitat-forming species (see **6.2**).

NOTE 9 The likelihood of natural colonization by targeted habitat-forming species can be considered along with the feasibility of augmentation efforts to best inform inclusion in nature-inclusion goals.

5.2.3 Set nature-inclusion goals

Projects incorporating nature-inclusive design of marine structures should articulate specific quantifiable nature-inclusion goals.

NOTE 1 If developing designs without a specific project location in mind, a broader approach to goal setting may be taken given the wider environmental setting for their intended use.

Goals should be tailored to the specifics of the project and should aim to optimize the structures, thus either or both enhancing positive effects and mitigating negative impacts to local native habitats and species. When setting goals practitioners should aim to uphold the nature-inclusive design principles, especially optimization and harmony.

NOTE 2 Goals can target a broad array of organisms. For example, a goal might target the enhancement of surface coverage and diversity of native epibiota.

NOTE 3 Goals can also target specific types of organism. For example, a goal might target enhancement of habitat for a specific ontogenetic stage of a specific species, like to enhance the nursery habitat for juvenile Atlantic cod Gadus morhua.

NOTE 4 Goals can be targeted at keystone species, habitat building species or umbrella species, targeting such species can create benefits for entire ecosystems whilst keeping goals specific, readily measurable and more easily communicated.

Goals should make reference to specific ecological conditions so as to be testable via ecological monitoring. Goals should accord with at least one of three overarching scenarios:

a) mitigation of a negative impact of the structures to the existing baseline ecosystem (i.e. habitat and community);

b) promotion of conditions similar to those found in natural ecosystems in the region; and

NOTE 5 This could include the restoration of keystone biogenic habitats like coral reefs, oyster reefs and mangroves forests.

NOTE 6 This can include the restoration of natural ecosystems in the region within the historic context of the region.

NOTE 7 Consideration can also be made to the appropriateness of selected goals to the future environmental context of the region, including climate change predictions about the relevance of certain goals, especially historic goals that may not be appropriate to future environmental scenarios.

c) enhancement of ecological performance, to surpass that of a traditional structure to which nature-inclusive design has not been intentionally applied.

Whilst a project does not need to create goals aligning with all three overarching scenarios, all three overarching scenarios should be explored as potential options during goal setting.

Goals and the rationale for their selection should be documented during the design process and summarized in supporting documentation for nature-inclusive designs. Success criteria for the goals should be explicitly defined for subsequent performance assessment.

NOTE 8 For example, a success criteria aligning with BNG practice might be to achieve over a 10% net gain in biodiversity metrics in close proximity to the nature-inclusive structures.

NOTE 9 Goals may be revised iteratively during the design development process as more information and knowledge is accrued during the preparation and design phases of projects.

Goals should be specific, measurable, achievable, realistic and time-bound (SMART).

NOTE 10 The distinction between "achievable" and "realistic" in the context of SMART goals, although subtle, is significant for setting effective objectives. The nuance between these two lies in their focus: "achievable" is more about the internal capabilities and resources to reach a goal, while "realistic" looks at the external environment and the goal's relevance and practicality within that context.

5.2.4 Define intended approaches to achieve nature-inclusive design goals

*COMMENTARY ON **5.2.4***

This stage in the procedure can be considered as postulating how and why the nature-inclusive designs will effectively integrate with marine habitats and species toward the defined goals.

The approach by which the nature-inclusive designs are to integrate the requirements of target species and/or communities should be documented. Reference should be made to the nature-inclusion goals, BNG targets (if applicable) and predicted environmental impacts of the project's marine structures. Empirical evidence in scientific literature should be referred to regarding the ecology of target species, communities, or habitats, and regarding ecological engineering good practice.

NOTE 1 Approaches might be targeted at facilitating such essential ecological processes as settlement, growth, reproduction and survival.

NOTE 2 Nature-inclusive design can be targeted at facilitating these processes via mechanisms like refugia provision, food supply, increased niche availability, protection from human exploitation, provision of a favourable environment, reduced environmental stressors or a reduction in the impact of the structure itself.

Practitioners should take into account the direct effects that the structural modifications will have and the indirect effects that the ecological consequences of such modifications will have in the ecosystem.

5.2.5 Incorporate nature-inclusive structures and nature-inclusive design features that align with the goals

*COMMENTARY ON **5.2.5***

This stage in the procedure can be considered as defining what features make a structure nature-inclusive compared to non-inclusive.

In the incorporation of design features reference should be made to the goals, approaches behind the selection and incorporation of design features, and the ecological mechanisms by which the designs are intended to meet the goals.

For the incorporation of nature-inclusive design features, practitioners should take into account the following non-exhaustive list of points:

a) the site-specific characteristics, such as substrate type (physical and chemical characteristics), water depth, metocean conditions and exposure to sunlight, and what features and considerations (e.g. the placement and orientation of the design features) should be incorporated to mimic the natural conditions needed to attract and support the target species and/ or communities, as specified in the defined approach (see **5.2.4**);

b) designing features of sizes throughout the range of spatial scales relevant to the project and the nature-inclusion goals;

c) the creation of microhabitats with nature-inclusive features;

d) increasing the complexity and diversity of microhabitats within the overall novel habitat of the project development site when targeting the enhancement of native biodiversity with designs;

e) the connectivity between microhabitats within the project site and the connection to habitats outside of the project site, including the larval supply of target species;

f) using terminology for design features that is easily relatable to the specific feature type. However the features are defined, the definitions should be explicitly detailed in design documentation. Practitioners should refer to scientific literature for established terminology where available but may choose their own definitions where adequate accepted definitions are unavailable.

NOTE 1 For example definitions of microhabitat features can be found in resources like Baxter et al. [25] and Evans et al. [3].

Designs should consider the spatial and environmental variability in the locality of the project area, and the orientation and positioning of structures in relation to prevailing environmental conditions.

Nature-inclusive design features should be supported by empirical evidence in scientific literature or designated as experimental if the evidence base is scant. Experimental features should be justified ecologically by a competent person. Experimental features should be studied to assess their efficacy and thus provision for their monitoring should be included during the planning process.

*NOTE 2 See Clause **7** for guidance on setting up monitoring programs during planning.*

Experimental features should be avoided when post-build study is not feasible or provided for within the project scope.

NOTE 3 Features might be included that are present locally within natural habitats at the project site or in the local seascape. Structures and features might be designed to mimic the natural environment of the target organism(s).

5.2.6 Verify practicality and engineering efficacy

The practicality and engineering efficacy of the structure(s) for their intended purpose should be verified. Nature-inclusive design should not compromise the efficacy and safety of the structures for the intended purpose, including such factors as deployability, ease of removal, maintenance, durability and stability.

Nature-inclusive designers and engineers should collaborate to verify that designs deliver the purpose of the structures and meet applicable codes and standards for structural design, transport and installation and safe use. Implementation of the structures should be considered in their design (see Clause **6**).

5.2.7 Assess and mitigate risks

*COMMENTARY ON **5.2.7***

This subclause does not provide comprehensive guidance of risk assessment methods which fall outside of the scope of this PAS, it does however include some key criteria that are specific to nature-inclusive marine structures to guide the users in performing effective subject-specific risk assessments.

A risk assessment for the nature-inclusive designs should be performed. Risk categories should include environmental, engineering, cost analysis and health and safety.

Risks of encouraging marine life should be assessed.

Commented [MR16]: Recommend amending to “Risks to the engineering purpose…”. The footnote explains but this sentence itself is not helpful.

NOTE 1 In some instances, marine epibiota might create undesirable effects to the function of the structures. For example, increased biomass and hydrodynamic loading can adversely affect structures. Additionally, in accordance with BS 6349-1-1, intake and discharge pipes require particular attention as excessive marine life can restrict the functionality of these components.

NOTE 2 Nature-inclusive designers and engineers might choose to collaboratively perform risk assessments to consider the effects of the marine life on the operational efficacy of the structures.

Nature-inclusive design for the enhancement of epibiota biomass should not be applied to high-risk areas or areas that require frequent inspection and monitoring of the bare structure itself.

Practitioners should take into account historical evidence of environmental impacts of structures to marine ecosystems.

NOTE 3 The introduction of structures can alter the local habitat type from one to another, which presents a host of potential risks. For example, see Heery et al. [19], Table 1, for a list of documented effects of constructing marine structures on natural soft substrate habitats.

The risk of introducing or aiding the proliferation of non-native species (NNS) should be considered as a potential unintended outcome and mitigated against in the design phase where feasible.

NOTE 4 The risks of NNS are especially high with the introduction of structures in areas where naturally hard substrates do not occur within an ecological seascape, and thus native communities are less likely to effectively develop and compete with NNS, see Airoldi et al. [26], for example, in the intertidal zone of wind farm turbines, see De Mesel et al. [27].

NOTE 5 NNS are an environmental risk for any marine structure, not just nature-inclusive structures. Whilst nature-inclusive design is unlikely to completely prevent settlement by NNS if they are present within an area on similar substrates, evidence suggests that nature-inclusive design features like modified complex surfaces can *help to mitigate the impact of NNS by effectively catering for diverse and abundant native communities; thus, designs could be targeted as such, for example, see Marchetti et al., [28].*

Nature-inclusive structures should not adversely affect populations of other (non-target) species that use the site – for example by attracting predators or out-competing habitats that they depend upon.

Experimental features and the risks of using such features should be assessed, especially if there is a risk of unintentionally degrading natural environments.

An assessment should also be made of the other users of the marine environment and the impact that nature-inclusive structures might have to their use of the marine space.

Mitigation measures to reduce the impact or probability of risks should be detailed in assessments and enacted on subsequent designs as appropriate.

NOTE 6 If required, mitigation measures may be delineated as additional goals of the nature-inclusive designs.

5.2.8 Integrate aesthetics where required

The importance of aesthetics should be assessed.

NOTE 1 Aesthetics can be considered as an aspect of designs depending on applicability for the specific project.

If the structures are to be accessible and viewed by the public, then aesthetics should be taken into account.

NOTE 2 Aesthetics can be tailored to suit the local aesthetic environment. When considering the aesthetic of the structural design in the context of the project, designers can consider:

a) local cultural value, historical significance, architectural style and regulatory plans;

b) public opinion;

c) geomimetic styles, i.e. replicating geological structures; and

d) biomimetic styles, i.e. replicating marine biological structures.

5.2.9 Use habitat metrics to predict efficacy

Habitat metrics should be used to predict and communicate the efficacy of the nature-inclusive designs toward the nature-inclusion goals (see **5.2.3**).

Commented [MR17]: Industry standards for metrics, particularly relating to marine net gain are not yet well defined. Without standard practice in place, our members suggest this makes this challenging.

Further, SR members question where have the noted suggestions been derived from?

NOTE Metrics can be simple or complex. Metrics for quantifying predicted efficacy of nature-inclusive designed structures could include but are not limited to:

a) rugosity at low resolution (dm – m);

b) rugosity at high resolution (cm);

c) interstitial volume (cm^3-m^3);

d) water pooling volume (cm^3-m^3);

e) density of microhabitat features;

f) diversity of microhabitat features; and

g) vertical relief.

5.2.10 Document the design rationale aligning with the design procedure

The rationale for the nature-inclusive designs following the procedures in **5.2** should be documented. Practitioners should therefore describe the site, define the goals and how they were selected, the design mechanisms, features and aesthetics, the scientific basis for design, practical considerations, risk assessment, habitat metrics, along with the communication of designs visually with technical drawings.

5.3 Visual communication of designs

Designs should be conveyed visually through technical drawings for effective communication among project participants and stakeholders. Technical drawings should be provided to aid effective EIA and implementation of selected designs.

NOTE 1 3D models or visualizations can also be integrated alongside traditional 2D drawings. 3D models and visualizations can provide more intuitive and explorative understanding of the design, especially for non-technical stakeholders.

Technical drawings should comply with local standards and reference industry standards.

NOTE 2 For example, BS EN ISO 128, the technical product documentation series and associated standards such as BS EN ISO 5457.

Drawings should adhere to the same industry-standard conventions as the wider project team.

NOTE 3 Adhering to the conventions of the project team is key for checking that drawings are easily and accurately understandable by professionals involved in the project.

Detailed sections and elevations should be provided to illustrate the technical details of nature-inclusive design features, as defined in supporting documentation. Location and position of nature-inclusive designs should also be visually mapped if relevant.

NOTE 4 Reference information can be provided as necessary, including indicators of north direction, adjacent structures, or key landscape features. Reference information helps in placing the design in context and understanding its interaction with the surrounding environment.

NOTE 5 Practitioners can include a constraints and opportunities plan with visual communications, to include designated and landscape features, heritage assets and other local nature recovery projects and initiatives.

Drawings should make use of clear annotations and descriptions to provide additional information that cannot be easily represented visually.

5.4 Lifecycle assessment (LCA)

Practitioners should conduct LCAs to guide the selection of the most environmentally sustainable designs and implementation strategies, and to communicate environmental impacts to stakeholders in the project.

NOTE 1 LCAs may be performed in a staged approach, to different levels of scope depending on the stage of project and practicability. Full standardized LCAs can be completed to provide a comprehensive analysis involving a detailed estimate of environmental impacts associated with all the stages of a structure's lifecycle. Alternatively, preliminary LCAs can be performed during early project development to aid optioneering without generating high costs and information intensity during early project development, whilst verifying that wider environmental impacts are considered early in the project.

NOTE 2 The goal of a preliminary LCA might be to identify the sources of the most significant environmental aspects and areas for impact reduction, rather than providing a detailed and comprehensive analysis. A preliminary LCA can help narrow down the choices to the most promising options, which can then be analysed in more detail at later stages. Preliminary LCA can allow for the rapid comparison of different design options and can inform decision-making by highlighting the relative environmental impacts of each option.

Any purportedly comprehensive LCA should be completed in accordance with BS EN ISO 14040 and BS EN ISO 14044.

NOTE 3 To ensure transparency, the environmental impact of marine structures and/or materials can be documented using Environmental Product Declarations (EPDs) based on LCAs.

At the time of decommissioning, plans should be made to perform multi-criteria decision analysis (MCDA) that incorporates detailed LCA (see Clause **8** for decommissioning planning guidelines).

NOTE 4 Due to the uncertainty associated with decommissioning methods in the future, those performing comprehensive LCA of structures during early project phases might choose to reduce the scope to exclude detailed decommissioning plans and include greater detail in production, deployment, and maintenance and monitoring phases.

NOTE 5 Practitioners can consider potential decommissioning scenarios or average industry decommissioning impacts to approximate the impacts of decommissioning in advance.

*NOTE 6 See **4.6** for guidance on how LCA results can be incorporated into project optioneering.*

NOTE 7 Attention is drawn to national regulatory requirements regarding decommissioning.

LCAs should be revised as projects evolve and built upon with increasing information as projects progress.

Scope, assumptions and limitations of all LCAs should be clearly communicated to project partners. Regardless of the scope, the methodologies, data sources, assumptions and limitations should be accurately documented within LCA reports.

NOTE 8 Developing tailored communication strategies, including visual aids and summary reports, can enhance stakeholder engagement and facilitate informed decision-making based on LCA outcomes.

LCA should not be viewed in isolation but as a component of a broader environmental assessment strategy that includes ecological impact assessments, sustainability appraisals, and social impact studies, offering a holistic view of a project's environmental footprint.

NOTE 9 LCA software tools can aid the performance of LCA and can facilitate industry specific preliminary LCA processes to streamline early analysis.

5.5 Material selection

*COMMENTARY ON **5.5***

This subclause provides a number of provisions that aim to ensure that structures incorporating nature-inclusive design consider ecosystem and environmental impacts in the materials used for their creation. The selection of an optimal material can be a complex decision to make, relying on numerous factors, that can potentially conflict given the specifics of a given scenario. Guidance is therefore provided to enable the user to identify these factors and to adequately balance the decision-making process. The subclause consists of broad provisions that are relevant to all material types which can be used in the production of marine structures, and specific provisions for materials for which specific relevant guidance is applicable.

Users should undertake LCA (see **5.4**) and optioneering processes (see **4.6**) to assess the optimal material selection holistically for designs and to balance potentially conflicting factors.

NOTE 1 EPDs and audited LCA results for individual material sources are more reliable forms of information for integration with LCA and optioneering processes during material selection, especially when produced in alignment with standard methods for LCA – at the time of publication being BS EN ISO 14040 and BS EN ISO 14044 and following specific product category rules such as those set out in BS EN 15804.

NOTE 2 Whether a supplier has an environmental management system that abides by BS EN ISO 14001 can be a factor in evaluating the sustainability of a material. Suppliers that comply with BS EN ISO 14001 demonstrate a commitment to environmental sustainability, good environmental practices, continuous improvement and effective risk management.

Marine structures incorporating nature-inclusive design should be designed for production with materials that are sustainably sourced and have a low environmental impact throughout their life cycle. This includes considering the extraction process, manufacturing energy consumption, transport, and the potential for recycling or repurposing at the end of the structure's life. Carbon emissions should be included in assessment of impacts during material selection, such that low carbon options should be used, and carbon neutral or negative should be prioritized if available.

Materials that are a waste by-product, recycled or have high recyclability potential should be prioritized, to avoid using primary materials where possible.

Producers should verify that the materials match the required technical performance for the structures as dictated in the relevant standards, good practice and project specific engineering calculations.

NOTE 3 The determination of technical performance to project requirements can be performed via a process of equivalent performance testing, subject to assessment by competent persons. Equivalent performance testing can be used to compare the technical performance of more innovative materials to selected benchmarks *specified in industry standards and good practice, typically with the goal that defined testing parameters match or exceed those of the benchmark.*

Materials should be cost feasible with the project scope.

NOTE 4 Accurate material costs can improve the efficacy of optioneering practices.

Materials should be safe for use in terms of toxic chemical content and the rate of toxic chemical leaching into the surrounding environment.

NOTE 5 If using innovative materials, these can be tested for toxic leaching with standardized tests like those specified by the BS EN 16637 series. See BS EN 16637-1 for selection of appropriate tests.

NOTE 6 Safety can be determined by comparing to pre-defined benchmarks, for example, the Dutch Soil quality decree sets values of safe leaching for construction materials [29].

Where concrete is to be used, lower carbon concrete should be used in adherence to contemporary good practice for sustainability. At the time of publication, lower carbon concrete should be produced with alternative binder systems, adhering to BSI Flex 350 v1. Suppliers of lower carbon concrete should provide a validated carbon footprint, adhering to the requirements of emissions reporting in BSI Flex 350 v1 and achieving an embodied CO_2 rating not greater than benchmark rating A for the relevant strength class according to the ICE low carbon concrete route map [30].

Synthetic plastic components should be avoided, reduced and replaced with alternatives. Synthetic plastic components should not be the primary, majority constituent proportionally of a nature-inclusive structure or a structural feature where nature-inclusive design is applied.

Commented [MR18]: Noting that, particularly for floating offshore wind projects, floats and nylon moorings may be the only technically feasible solution.

Steel chain moorings may also lead to increased scaring of the seabed.

NOTE 7 Plastics are a material with environmental risks associated with their use long term in the ocean, counter to the ethos of nature-inclusive design.

The degree of risk probability and impact of using plastic materials, if they are components that cannot be avoided, reduced or replaced, should be assessed on a case-by-case basis.

NOTE 8 Use of LCA and optioneering can help to select designs and alternatives materials that mitigate the risks of plastic components.

Practitioners should select materials that are compatible with marine organisms, especially native biota and organisms specified in nature-inclusion goals.

NOTE 9 Practitioners might choose to perform an assessment of the potential requirements for replicating existing substrate conditions to aid in material selection.

NOTE 10 Practitioners might choose to select materials that contribute, along with the design, to the aesthetic value of the area, respecting the local landscape and cultural context; especially in areas accessible and visible to the public.

Materials should contribute to the aesthetic value of the area, respecting the local landscape and cultural context.

The locality of material sources should be taken into account in material selection, with preference made to more local materials where available, in order to reduce transportation emissions and support local economies.

6 Implementation of nature-inclusive structures

6.1 Production

*COMMENTARY ON **6.1***

It is not within the scope of this PAS to detail the safe and quality production of nature-inclusive marine structures. There are, however, certain criteria that need to be considered during production that fall outside of the scope of existing good practice and this has been included in this subclause.

Environmental impacts of logistical processes and deployment methods should be integrated with the production of the structure, in life cycle assessments and optioneering, so as to inform the development of projects with minimal impacts.

Nature-inclusive structures should be constructed in a location that minimizes project energy usage and greenhouse gas emissions, bearing in mind the transportation of materials to the production site and subsequently, the transportation of the structures to the project site. A systematic approach should be developed to evaluate and compare the environmental impact of potential production locations, including a quantifiable assessment of emissions from material transportation and the production process.

Commented [MR19]: Our members highlight that whilst this is an important consideration, it must be acknowlkedged that suppliers may be limited, particularly until the market matures.

*NOTE 1 Tools or software that can estimate carbon footprints can inform the selection process. See **5.4** for more guidance.*

Locations that facilitate the use of locally sourced materials should be prioritized, thereby reducing transportation distances and supporting local economies. The rationale for location selection should be documented, including environmental, economic, and logistical considerations, to check transparency and stakeholder alignment.

Local materials should be used to reduce transportation emissions and support local economies (see **5.5**).

NOTE 2 Using local materials can also aid better integration of the project structures with the local seascape, ecology and community.

It should be verified that the nature-inclusive design features adhere to those specified in design documentation.

Identification of long and short lead time items should be performed during the planning process to check effective product execution.

6.2 Augmentation with habitat-forming species

*COMMENTARY ON **6.2***

Practitioners might augment structures with habitat-forming species via the outplanting, transplanting or pre-settlement (a.k.a "seeding") of live organisms on to the structures during implementation. This might be performed to facilitate relevant native habitat-forming taxa (i.e. bivalves, corals, canopy-forming algae, branching coralline algae) thus providing relevant ecological services and functionalities further promoting native biodiversity. Nature-inclusive structures in this way can be used directly in the restoration of denuded keystone species, especially those with hard substrate habitat requirements.

Only native species should be actively augmented to the structures.

Thorough risk assessments should be performed regarding the risk of unintended consequences of introductions. The consequences of project development should be considered in the predicted efficacy of such endeavours.

Augmentation with habitat-forming species should be performed in the most efficient manner in terms of operational environmental impact and recruitment success (i.e. survival of the augmented organisms). Biosecurity plans should be created regarding the movement of live organisms and with contemporary industrial good practice, and good practice in scientific literature.

NOTE 1 Attention is drawn to legislation relating to biosecurity plans.

The ecological requirements of the habitat-forming species should be understood. Research should be directed at the preferred environmental conditions of the species, its interactions with other species and function within the ecosystem.

NOTE 2 Practitioners can consider engaging with local communities, ecologists, and other stakeholders for insight.

NOTE 3 Sources of augmented organisms might be natural populations in the region or artificial populations in captive breeding programs.

Source populations should be assessed for health and sustainability. Source populations should be from captive breeding programs where these populations are suitably healthy, to avoid denuding natural populations. The risks of disease and reduced genetic diversity in source populations should always be included in assessments.

If individuals or propagules are to be removed from natural populations, this should be done in a manner that does not negatively impact the source population, following sustainable practices and as part of a managed recovery or propagation program. Biosecurity measures should be taken according to current good practice for the species in question, to avoid transportation of non-native species or diseases.

An augmentation plan should be developed that minimizes stress and maximizes the survival rate of the species.

NOTE 4 This can involve choosing the right time of year, preparing the species for transportation, planning for a smooth transition to the new habitat and other measures to reduce stress.

NOTE 5 Practitioners can design the project to enhance habitat connectivity. This involves connecting to existing natural habitats to promote ecological linkages.

A robust monitoring plan should be included to track the establishment and growth of the habitat-forming species. Monitoring should assess both the health of the augmented species and the overall ecological performance of the project in accordance with Clause **7**. The management strategy should be adapted based on monitoring results.

It should be verified and documented that the design and augmentation practices comply with good practice for ecological restoration and habitat creation, including scientific good practice in peer-reviewed literature.

NOTE 6 For example, in the UK for native oyster outplanting, users are advised to consider the guidance of the Native Oyster Network (e.g. Preston et al., 2020 [31]).

The risk of discontinued funding and project cancellation should be assessed.

NOTE 7 Practitioners can consider utilizing aquaculture infrastructure in the area or at the site for cultivating habitat-forming species and facilitating their survival during outplanting exercises.

7 Ecological monitoring of nature-inclusive structures

*COMMENTARY ON **CLAUSE 7***

This clause provides overarching monitoring guidance for the assessment of ecological efficacy of nature-inclusive structures. Like any project, users are advised to follow good project management practice for the fulfilment of monitoring programs, in addition to the provisions provided in this clause.

7.1 General principles and planning requirements

Claims of effective nature-inclusive structures should be backed by empirical evidence garnered through ecological monitoring.

Evidence of the same design from different areas can be used as supporting evidence for nature-inclusive design but site-specific evidence should be used to substantiate claims of a nature-inclusive structure for every unique project setting.

The ecological monitoring should ask the primary questions:

a) Have the nature-inclusion goals been achieved? (see **5.2.3**).

b) Have the structures achieved another significant benefit to nature outside of the designated nature-inclusion goals?

Commented [MR20]: Our members question have they resulted in unintended consequences?

The monitoring program should aim to answer these questions in the context of the surrounding and underlying baseline habitat, and with reference to traditional structures for which nature-inclusive design has not been applied, where available.

Ecological monitoring programs should be developed according to the scientific methods reported in contemporary regional good practice and scientific good practice in peer-reviewed literature. The program should include hypotheses tailored to monitor the efficacy of nature-inclusive designs according to the specific nature-inclusion goals set during the design development (see **5.2.3**).

NOTE 1 Additional hypotheses can be added to bolster monitoring results with additional information beyond the efficacy of structures at achieving the nature-inclusion goals.

Monitoring programs should also be tailored to the identified risks for each project as required. NNS should be identified and enumerated and the risk of introduction or proliferation via the nature-inclusive designs should always be included in analysis of resulting datasets.

NOTE 2 The scale of effort in monitoring programs can be tailored proportionally to the scale of a project as required. For example, a smaller project may reduce the number of replicates, the complexity of the data collection methods and the number of sample periods, reducing the onerousness of monitoring, increasing the feasibility of monitoring performance and still producing effective data and results on nature-inclusion efficacy.

Every monitoring program should have a plan. Prior to starting ecological monitoring, the plan should detail:

1) research questions and hypotheses in relation to the nature-inclusion goals (see primary research questions above);
2) experimental design (see **7.2**);
3) estimated cost, time and resource requirements;
4) available budget for the monitoring program;
5) geographical, temporal and ecological details of monitoring;
6) standardized data collection methods and rationale for selection;
7) roles and responsibilities of different project participants and stakeholders in the monitoring program;
8) plans for data management;
9) format, frequency, and recipients of monitoring reports;
10) working life of the structure(s);
11) scheduled timeline(s) with key milestones detailed;
12) limitations of the plan including adherence to any budget restrictions); and
13) risk assessment including scientific, health and safety, environmental and operational risks.

7.2 Experimental design of ecological monitoring

An experimental design should be documented that includes details of when, where and how ecological monitoring is to take place, to collect data to answer the primary questions of ecological monitoring.

The experimental design should be based on three overarching plausible scenarios as appropriate to the project, the structures and the nature-inclusion goals:

a) The nature-inclusion goal is to mitigate the impact that a structure causes on the pre-existing ecosystem. In this instance, a Before After Control Impact (BACI) or Before After Gradient (BAG) research designs should be implemented. This means that monitoring should be performed in at least one period before and one period after the placement of structures. The monitoring should take place at the location of the structures, designated as the “impact” site and at a control site with a similar condition to the pre-impact

Commented [MR21]: Our members highlight that it is important to allow flexibility in monitoring design so that it is appropropriate to the habitat/species and site as well as the Nature-Inclusive goals considering factors such as baseline data in circumstances where NID structures are deployed in an already operational site, or availability of suitable control areas.

baseline where the very same perturbation did not occur. Before and after samples should be performed in the same season from one year to another.

b) The nature-inclusion goal is to promote conditions similar to those found in natural ecosystems in the region. In this instance, a control treatment design should be implemented, monitoring over time to check for the convergence of the nature-inclusive treatment condition towards the control site condition. The monitoring should take place at the location of the structures, designated as the “Treatment” site and at a control site with a desired condition.

NOTE 1 For example, the creation of similar conditions to a rocky or biogenic reef habitat.

c) The nature-inclusion goal is to enhance ecological performance, to surpass that of a traditional structure to which nature-inclusive design has not been intentionally applied. In this instance, a control treatment design should be implemented, monitoring over time to check for the divergence of the ecological performance of the nature-inclusive treatment from the traditional control. The monitoring should take place at the location of the nature-inclusive structures, designated as the “Treatment” site and at a control site with traditional non-nature-inclusive structures and similar environmental conditions.

Samples should be planned for the most meaningful season in accordance with the local ecology and nature-inclusion goals. Periods of monitoring after the placement of structures should include at least one long-term period, when the biological community has undergone ecological succession and developed into a mature community.

NOTE 2 Judgement is required for how long a mature community is likely to be achieved. Only repetitive monitoring can reveal if a relatively steady state has been achieved. Five years is an approximate minimum amount of time for climax communities developing on marine structures to be achieved.

The sampling design should be replicated in time and space to maximize the power of the test but without introducing biases such as pseudoreplication or other sources of confounding. It is the responsibility of the survey scientist-in-charge to set the adequate replication considering project aims and constraints, along with technological and methodological advancements.

7.3 Data collection methods

Data collection methods selected should align with contemporary ecological good practice in the project region and scientific good practice in peer-reviewed literature. In particular, given the purpose of nature-inclusive structures to encourage nature recovery and/or net gain, non-intrusive or low-intrusive sampling methods should be selected where possible, e.g. reducing the collection of physical biological samples to eDNA sampling, plankton trawls and sediment grabs, and reducing the quantity of biological material taken from the marine environment as much as practicable given the requirements of the ecological monitoring program. Method selection should be made with consideration to the value of historical datasets in the region.

NOTE 1 Methods can be selected to target different ecological groups. A useful classification to delineate methods can be to classify organisms based on habitat-usage into epibiota, endobenthos, nekton and plankton and target methods toward these classifications. Methods and analyses can be further focussed on target species that are delineated in the nature-inclusion goals, indicator species, keystone species or umbrella species for informative purposes as suitable.

NOTE 2 Data submitted by citizen scientists may be utilized in monitoring programs, so long as standardized methods are used and proficiency of collectors is vetted.

NOTE 3 Methods that are standardized across multiple projects can be used. Data can then be pooled across multiple projects in meta-analyses for a deeper understanding of nature-inclusive design.

NOTE 4 The use of methods that align with historical datasets can help to increase the validity of interpretations by setting the project within wider spatial or temporal contexts.

Risk Assessed Method Statements (RAMS) should be produced for all monitoring field operations. Safety protocols should follow good practice, relevant to the industrial and environmental setting, for marine field operations. Monitoring exercises should be coordinated between all required project participants, especially between site managers and monitoring operatives.

7.4 Statistical methods

Statistical methods should be used to test hypotheses. Statistical methods should be selected following contemporary ecological good practice in the region and scientific good practice in peer-reviewed literature. There should be a sufficient sample size to reduce type 1 and type 2 errors.

NOTE 1 Tools like power analysis and collector's curves can be used to assess if the sample size is sufficient.

NOTE 2 Example thresholds for assessing results of power analyses are a threshold of 0.05 for type 1 errors and 0.20 for type 2 errors – equivalent to 0.80 power.

NOTE 3 Pilot studies can be performed in the process of creating monitoring plans. Pilot studies can be used to inform the selection of methods and an appropriate sample size. If using a pilot study to produce assessments of variability in the local environment then an adequate number of samples need to be included for accurate variability. This is project specific but a good starting rule of thumb is 20-30 sample replicates.

7.5 Reporting and communication

Local stakeholders, including local communities, should be engaged in the monitoring process, where it is safe and practical to do so. This can provide additional observations which result in the project's benefits and any concerns should be understood and addressed.

NOTE 1 For example, the timing of reporting can be communicated to local stakeholders and could be adjusted to suit the wishes of local community members.

Reports of monitoring programs should be made available to project stakeholders on request. Reports or summaries thereof should be actively disseminated to local stakeholders in the project including local community members. Reports should include detailed methods statements including data collection methods, timing, location of samples, statistical methods and details of equipment used. Reports should make clear reference to the original nature-inclusion goals and to the primary research questions to assess if effective nature-inclusion has been achieved. Data should be made available for auditing purposes on request, including images, video footage and data tables.

Commented [MR22]: There may be commercial sensitivities around some data formats. Our members would wish to release monitoring information/reports only once these had been agreed with regulators.

NOTE 2 Reports can be submitted for peer review to improve the perceived reliability of results.

Multiple different biodiversity metrics should be developed and communicated in results to provide comprehensive inspection of the community (see Annex C for example metrics that can be utilized).

NOTE 3 Results might not include only a single biodiversity metric.

8 Decommissioning of nature-inclusive structures

*COMMENTARY ON **CLAUSE 8***

Decommissioning of marine structures is a rapidly developing practice. Users are advised to stay abreast of emerging developments in the field outside of this PAS, especially specific to the area and other particulars of the structure being decommissioned.

When decommissioning nature-inclusive structures, an evaluation of the value of the structures to the local ecosystem should be integrated into decommissioning option selection processes, alongside other key aspects such as technical feasibility and safety considerations. This evaluation should be comprehensive, incorporating a baseline ecological assessment before decommissioning to understand the current ecological value of the structure, including the organisms living on or around it, such as the species present, their abundance, and the ecological functions they provide. Practitioners should evaluate the ecological value of nature-inclusive designed structures with consideration of the current ecosystem around the structures, the baseline ecosystem before placement of the structures, and the historic baseline ecosystem in the region, prior to any significant anthropogenic alterations; on a case-by-case basis.

NOTE 1 There are potential environmental benefits from a nature-inclusive structure's presence that would be removed if the structure was removed, for example, potential addition of value for larval supply of conservation important species like cold water corals, see Henry et al., 2018 [32].

Evaluation of the structures' value to local ecosystems should be performed by a competent person using evidence from the results of ecological monitoring programs, referring to the efficacy of nature-inclusive design against the assigned nature-inclusive design goals for the structures. Practitioners decommissioning nature-inclusive design should integrate the considerations of ecological value of the structures with contemporary good practice, in the region at work.

NOTE 2 Attention is drawn to relevant legislation and regulatory frameworks with regard to decommissioning.

NOTE 3 Practitioners can perform an impact assessment to integrate the structure's value into decommissioning options.

If performed, the impact assessment should include direct impacts, like the physical removal of habitats and indirect impacts, such as changes in local water quality or sedimentation patterns. Ecological monitoring programs to test the efficacy of nature-inclusive design should also be used as evidence in impact assessments.

For each decommissioning option, the assessment should consider the impact on:

a) organisms directly associated with the structure (e.g., oysters on the reef); for example, if a protected species is inhabiting the structure, then the impacts of different decommissioning strategies on this species should be incorporated into the decommissioning decision making process;

b) the surrounding baseline habitat and the wider ecosystem; and

c) the connectivity with nearby habitats and any potential fragmentation effects.

MCDA should be used to holistically assess decommissioning options over various criteria including costs, environmental impacts, health and safety risks and feasibility. When completing MCDA, practitioners should incorporate the impacts to the structure's ecological role in the locality as a criteria in environmental impact scores for the various options.

NOTE 4 Three MCDA approaches of relevance to the decommissioning of marine structures, are:

a) comparative assessment (CA);

b) net environmental benefit analysis (NEBA); and

c) best practicable environmental option (BPEO).

Users are encouraged to refer to up to date literature on MCDA best practice for marine structure decommissioning, examples at the time of publication include Sommer et al. [33] and Nicolette et al. [34].

Practitioners should develop mitigation strategies to minimize the negative impacts of decommissioning, including the consideration of in-situ decommissioning options to retain the ecological function of the structure.

NOTE 5 This might include timing the decommissioning to avoid sensitive periods or implementing measures to protect or relocate organisms. Compensation measures can be considered if significant negative impacts are unavoidable. This could involve creating new habitats elsewhere or enhancing existing ones to offset the losses caused by decommissioning.

Plans should be made for post-decommissioning monitoring to assess the actual ecological impacts and the effectiveness of any mitigation or compensation measures. Management strategies should be adapted based on monitoring results to check the long-term health and sustainability of the ecosystem.

Commented [MR23]: Our members ask is this intended to include retention of the NID structure in circumstances where the project of which the NID structure is a part is due for decommissioning?

Commented [MR24]: Suggest linkage to other government guidance related to consideration of decommissioning options?

Commented [MR25]: Whilst the importance of NID in marine developments is acknowledged developers will face significant commercial challenge in gaining support for such measures if there is a continual commitment to compensate for the the loss of benefits achieved.

Commented [MR26]: The general approach for decommissioning an Offshore Wind Asset is to remove all the asset. Where NID is incorporated into an offshore structure (such as a turbine foundation) which is removed, then would monitoring be required?

NOTE 6 Engaging stakeholders, including local communities, conservation organizations and regulatory bodies, in the decision-making process is crucial for verifying the chosen approach aligns with conservation goals.

The decommissioning planning process should be documented, including the baseline assessment, monitoring data, comparative analysis, stakeholder consultation outcomes, decision criteria and any planned mitigation or compensation measures.

NOTE 7 Practitioners can choose to perform a comparative assessment balancing the value of the ecosystem baseline prior to placement of the structures against the value of the new ecosystem baseline pre-decommissioning, with the structures present. Such comparisons can be informed by ecological information and the development of decision criteria:

Ecological information for comparing pre-build and pre-decommissioning ecological states should include:

1) biodiversity metrics, for example, species diversity and abundance (see Annex C);
2) ecological functions and services (e.g. nursery grounds for fish, feeding grounds for birds);
3) habitat connectivity and its role in the larger ecosystem; and
4) distribution and prevalence of the project site biotopes within the wider seascape, evaluating their ubiquity or rarity.

NOTE 8 Decision criteria when balancing pre-build and pre-decommissioning ecological states can consider:

a) conservation priority of the species and habitats involved;

b) potential for habitat restoration or creation to compensate for any losses; and

c) broader ecosystem impacts and the potential for cumulative effects.

Annex A (informative) Checklist of good practice

NOTE Attention is drawn to national regulation regarding marine planning and licensing.

A.1 General

The questions given in **A.2** to **A.8** can be used as a basis for checking effective practice when reviewing the quality of nature-inclusive design structures and their management.

A.2 Integration with planning (see 4.2 and 4.3)

a) Can the project managers evidence that they've integrated nature-inclusive design of marine structures within existing best planning practice for the project area?

b) Has the consideration of nature-inclusive design been integrated in environmental impact assessments, stakeholder engagement, BNG plans and documentation of planned mitigation measures?

c) Has documentation of the nature-inclusive design details been incorporated into project documentation?

d) Were environmental impacts considered early in the project?

A.3 Preventing the misrepresentation of nature-inclusive design (see 4.4)

a) Have the environmental impacts of the project been clearly communicated?

b) Are the benefits of the nature-inclusive design balanced with the overall impact of the project in application documentation and public communications?

Commented [MR27]: As above, timing and level of detail could be challenging to fulfil this.

Commented [MR28]: As above.

A.4 Engaging with stakeholders regarding nature-inclusive design (see 4.5)

a) What groups of stakeholders have been engaged in the development project?

b) What information has been garnered from stakeholders that can be used for nature-inclusive design?

A.5 Optioneering (see 4.6)

a) Were environmental effects, engineering efficacy, costs, social aspects and risks considered in the selection of nature-inclusive design options?

b) Did consideration of the environmental effects include local environmental impacts, potential benefits with nature-inclusive design and wider impacts through production and implementation?

c) Was optioneering with a multi-criteria evaluation or multi-criteria decision analysis performed?

d) How was the environmental effect of the structures scored within the multi criteria decision analysis?

e) Were the required factors considered in the analysis: integration with local ecosystems, wider environmental impacts, engineering efficacy, costs, social aspects (aesthetic, public acceptance, local heritage), local regulatory environment, stakeholder engagement?

f) How did the MCDA inform final selection of designs?

A.6 Nature-inclusive design of marine structures (see Clause 5)

A.6.1 Principles of nature-inclusive design (see 5.1)

a) How does the practitioner interpret the principles of nature-inclusive design?

A.6.2 Design development procedure (see 5.2)

a) Have all the steps of the nature-inclusive design procedure been completed and documented?

b) Are the approaches and design features supported by empirical evidence in the scientific peer-reviewed literature?

c) Are the approaches and design features supported by evidence or recommendations from other “grey” or non-scientific literature?

d) Have the features been clearly defined?

e) What are the nature-inclusive design goals?

f) What are the clear testable success criteria for the goals?

g) How do the goals align with optimizing the environmental effects of the structures?

h) Have the goals been developed using comprehensive compiled supporting information?

A.6.3 Visual communication of design (see 5.3)

a) Have the technical drawings been supplied for the designs?

b) Do the drawings state the standard conventions and adhere to them?

c) Are the standard conventions of the drawings the same as those used by the wider project consortium?

A.6.4 Life cycle assessment (LCA) (see 5.4)

a) Was a preliminary LCA performed to inform option selection?

b) Was a detailed LCA performed on the final selected option?

A.6.5 Material selection (see 5.5)

a) Is there evidence that the materials are non-toxic?

b) Are any plastic materials used in the structures?

c) What is the greenhouse gas footprint of the materials in the structures?

d) Have lower carbon materials been used?

e) Are the materials compatible with marine organisms?

f) Have locally sourced materials been selected?

A.7 Implementation of nature-inclusive structures (see Clause 6)

A.7.1 Production (see 6.1)

a) Is the production location efficient in terms of energy usage and greenhouse gas emissions, given transportation requirements of structures to the project site?

b) Do the structures match the specified nature-inclusive design?

c) Do the designers and manufacturers have industry specific experience?

d) Is the logistical strategy the most efficient in terms of energy usage and greenhouse gas emissions or have other factors e.g. cost been prioritized?

e) Has an efficient deployment strategy been developed in terms of operational greenhouse gas emissions, energy usage? And environmental impact?

A.7.2 Augmenting with habitat-forming species (see 6.2)

a) If augmenting the structures with habitat-forming species, have the practitioners adequately assessed the risks of introducing organisms?

b) Is there a risk that the augmentation program will damage natural populations of the habitat-forming organisms?

c) Does the augmentation program correspond with a managed recovery program?

d) Is there a monitoring program to record the efficacy of the augmentation?

A.8 Ecological monitoring (see Clause 7)

a) Can the practitioner back claims of the structures effectively, including nature with empirical evidence from ecological monitoring?

b) Is there a monitoring plan for the project?

c) Does the monitoring plan include the required details listed in **7.1** regarding general principles and planning requirements?

d) Does the monitoring plan include a BACI research design?

Commented [MR29]: Or other appropriate design

e) Do the data collection and statistical methods align with good practice in the scientific literature and ecological industry?

f) Have ecological monitoring reports or summaries thereof been made available to local stakeholders, including local communities?

A.9 Decommissioning (see Clause 8)

a) Have the marine species using the nature-inclusive structures been considered in the impact assessments and comparative assessments of decommissioning options?

b) Has a MCDA tool such as CA, BPEO or NEBA been used to holistically assess the decommissioning options?

c) Has the MCDA included assessment of criteria including costs, environmental impacts, health and safety risks and feasibility?

Annex B (informative)
Example of a feasible MCDA process for optioneering or decommissioning of nature-inclusive designed structures

*COMMENTARY ON **ANNEX B***

The following list are the steps with associated guidance for one plausible MCDA process. This structured approach is key for a balanced, transparent, and comprehensive evaluation of nature-inclusive marine structures, facilitating informed decision-making that aligns with environmental sustainability and project objectives.

B.1 Criteria definition

a) Identify criteria and sub-criteria: Begin by defining each criterion that will influence the decision-making process, such as ecosystem integration at the site and other criteria such as wider environmental impacts, cost, feasibility, and health and safety risks. For complex criteria, break them down into more manageable sub-criteria for a thorough evaluation.

B.2 Scoring methodology

a) Quantitative vs. qualitative scoring:

1) Quantitative scoring: Utilize numerical data for scoring wherever possible. For example, assess cost using actual financial figures.

2) Qualitative scoring: For elements like aesthetic appeal or stakeholder engagement, employ descriptive scales (e.g. low, medium, high) or Likert scales (ranging from strongly disagree to strongly agree).

b) Scoring guidance: Offer detailed instructions for assigning scores, with quantitative measures associated with specific value ranges and qualitative measures described through specific criteria.

B.3 Accounting for magnitude differences

a) Standardized scoring scale: Implement a consistent scoring scale across all criteria (e.g. 1-5 or 1-10), clearly defining what each score signifies.

b) Normalization: Normalize scores to the common scale to verify comparability, especially when different scales are used across criteria.

c) Weighting factors: Assign importance weights to each criterion reflective of its significance to the project's goals. Weights can be expressed as percentages or factors of a total sum (e.g. out of 100).

d) Combining scores: Multiply each criterion's score by its weight to emphasize certain criteria's importance over others in the decision-making process.

e) Sensitivity analysis: Conduct sensitivity analysis by adjusting weights and observing the outcome variations to gauge how changes in criteria importance affect the decision.

B.4 Considerations for qualitative scoring

a) Expert judgement: Leverage the knowledge of domain experts for qualitative assessments, providing context beyond numerical data.

b) Stakeholder input: Incorporate feedback from stakeholders for criteria related to social aspects or public acceptance.

c) Documentation: Thoroughly document the rationale behind qualitative scores to verify transparency and facilitate stakeholder understanding.

B.5 Final aggregation

a) Total score calculation: Sum the weighted scores for all criteria for each option to derive an overall performance score.

b) Comparative analysis: Conduct a comparative analysis of the total scores across options to determine which best aligns with project requirements and objectives.

NOTE Further guidance can be found elsewhere for specific MCDA tools for decommissioning, such as Best Practicable Environmental Option (BPEO) (Environment Agency & SEPA, 2004 [35]), NEBA (Nicolette et al., 2023 [34]), and CA (Oil and Gas UK, 2015 [36]). The IOGP report on Habitat retention strategies for decommissioned offshore jacket structures can also be a useful resource (IOGP, 2022 [37]).

Annex C (informative)
Biodiversity metrics

Examples of suitable biodiversity metrics for ecological monitoring of nature-inclusive marine structures are listed in Table C.1.

Table C.1 – Biodiversity metrics

Metric	Summary	Symbol
Species richness (alpha diversity)	Measures the number of different species present in a specific area.	S
Biomass	Assesses the total mass of all organisms within a given area or ecosystem.	B
Abundance	Counts the number of individuals of each species present in the area.	N
Functional diversity	Measures the range of different functional traits of species in a given area.	FD
Beta diversity	Examines the change in species composition from one area or habitat to another.	β
Shannon Diversity Index	Measures the diversity of species in a community as a product of species richness and the proportion of each species.	H'
Simpson's Diversity Index	Measures the probability that two individuals randomly selected from a sample will belong to the same species.	D
Community structure	Measures the identities ("composition"), number ("richness") and relative abundances ("evenness") of taxa in a multivariate way.	–

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