



**Cyfoeth  
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Wales

# Supporting the implementation of the Welsh National Marine Plan: Enhancing marine ecosystems

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# 1 Crynodeb Gweithredol

Yn 2017, cyhoeddodd Llywodraeth Cymru ddrafft cyntaf Cynllun Morol Cenedlaethol Cymru (CMCCd). Ar ôl ei fabwysiadu, bydd gan Cyfoeth Naturiol Cymru (CNC) ran allweddol i'w chwarae i roi'r cynllun ar waith, drwy ei swyddogaethau rheoleiddio (trefnau caniatáu a thrwyddedu morol) a chynghori.

Yn CMCCd, mae polisi drafft o'r enw 'ecosystemau morol cydnerth' (sef rhif ENV\_01). Yn ôl y polisi hwn: 'Dylai cynigion ddangos sut maent yn cyfrannu at ddiogelu, adfer a/neu wella ecosystemau morol'.

Mae CNC wedi comisiynu ABPmer i gynnal astudiaeth ddesg i'w helpu i ddeall yn well ac archwilio'r opsiynau ar gyfer gweithredu'r agwedd 'gwella' ar y polisi hwn. Gwnaethpwyd hyn drwy archwilio cyd-destun deddfwriaethol a pholisi'r pwnc 'gwella', yn ogystal ag adolygu cyfleoedd/technegau posibl y gellid eu defnyddio gan y gwahanol sectorau sy'n tueddu i ymgeisio am drwyddedau morol yng Nghymru. Ymchwiliwyd hefyd i'r egwyddorion y gellid eu cymhwysu.

At ddiben yr astudiaeth hon, dehonglwyd 'gwella' yn unol â'r diffiniad canlynol: 'Gwelliant amgylcheddol a allai ddwysáu neu gynyddu ansawdd, gwerth neu faint adnodd'. Hefyd, dylai datblygwr ymgymryd â gwelliannau yn ogystal â'r rheini a allai fod yn ofynnol i gyrraedd safon gyfreithiol (h.y. mynd y tu hwnt i unrhyw fesurau osgoi, lliniaru a digolledu sy'n ofynnol gan y gyfraith). Mae hwn yn ddehongliad cymharol gyfyngedig o'r cysyniad gwella, am fod y term hefyd yn cael ei ddefnyddio'n aml i ddisgrifio unrhyw gam a gymerir i gefnogi ymdrechion adfer neu ddigolledu ehangach. Fel y cyfryw, mae'r diffiniad o 'wella' a gymhwyswyd ar gyfer yr astudiaeth hon yn agos gysylltiedig â'r cysyniad 'enillion net' fel y'i gelwir, y deellir yn gyffredinol ei fod yn ddatblygiad sy'n gadael yr amgylchedd neu fioamrywiaeth mewn gwell cyflwr nag o'r blaen.

Mae'r adolygiad cyd-destun wedi arddangos bod amrywiaeth eang o ddeddfwriaeth a pholisi perthnasol sy'n cyfeirio at fesurau amgylcheddol sy'n gysylltiedig â'r cysyniad gwella, boed hwnnw yn ei ystyr ehangach neu fwy cyfyngedig. Hefyd, er bod cryn ddyhead i sicrhau gwelliant ecolegol yn yr amgylchedd morol, prin yw'r enghreifftiau ymarferol, y llwybrau ar gyfer gorfodi camau felly, ac yn wir y canllawiau i weithredu/dewis mesurau penodol. Mae hyn mewn gwrthgyferbyniad â mesurau sy'n rhaid eu cymryd yn gyfreithiol i osgoi/lleihau (lliniaru) a/neu ddigolledu effeithiau ar y rhan fwyaf o safleoedd dynodedig cenedlaethol a rhyngwladol, fel safleoedd Natura 2000. Am fod mwyafrif morlin Cymru (a'r DU ehangach) eisoes yn ddynodedig i raddau helaeth, mae corff sylweddol o brofiad mewn perthynas â mesurau lliniaru a digolledu yn yr amgylchedd morol, a moddau sefydledig o orfodi camau felly drwy gyfreithloni presennol. Hefyd, mae'r ffaith bod cynlluniau digolledu safleoedd Natura 2000 yn aml yn cael eu cynllunio gan gymhwyso lluosyddion sy'n benodol i brosiect er mwyn ystyried ffactorau fel ansicrwydd a phellter, yn gwneud cryn dipyn i egluro pam nad yw gwelliannau o fath 'enillion net' yn cael eu sicrhau'n gyffredinol yn ystod datblygiadau morol y DU.

Nodwyd ystod eang o enghreifftiau o fesurau gwella amgylcheddol drwy'r adolygiad llenyddiaeth. Mae hyn yn cynnwys mesurau ar safle ac oddi ar safle.



Yn nodweddiadol, mae mentrau gwella ar safle yn cynnwys cyflwyno gwrthrychau neu addasu strwythurau arfordirol artiffisial i gynyddu eu cymhlethdod a/neu arwedd eu harwynebau. Erbyn hyn, 'glasu'r llwyd' yw'r enw ar hyn, ac mae'n seiliedig ar y sail ecolegol fod bioamrywiaeth yn gynhenid fwy lle mae amgylchedd yn cynnwys nifer o ficro-gynefinoedd, cilfachau a llochesau rhag ysglyfaethwyr a phwysau amgylcheddol. Ar wahân i addasu strwythurau, mae lluo o fesurau eraill hefyd yn ddirnadwy ar gyfer gwelliannau ar safle, gan gynnwys creu cynefin drwy adlinio rheoledig (ac mae llawer o brofiad o hyn yn y DU) a gwella amodau i anifeiliaid fel adar magu ac adar clwydo.

Gall fod yn werthfawr cyflwyno cymhlethdod strwythurol i ddyluniad er mwyn gwella bioamrywiaeth leol. Er enghraifft, canfuwyd fel arfer bod gwelliannau amddiffyn a morglawdd yn gwella bioamrywiaeth leol o fewn 6 i 12 mis, yn berthynol i ddulliau 'busnes fel arfer'. Fodd bynnag, mae gwelliannau amgylcheddol ar safle yn tueddu i gael eu cyflawni ar raddfeydd lleol iawn a gallant fod ar ffurf 'garddio amgylcheddol'. Gall y raddfa hon o ymyriad (a ystyrir yn aml fel ymchwil) fod yn llai perthnasol yn yr amgylchedd morol ehangach (mewn cyferbyniad â datblygiadau daearol). Gall hyn fod yn arbennig o wir lle mae gan seilwaith morol swyddogaeth weithredol (e.e. waliau cei, sylfeini alltraeth ac ati), oherwydd gall gofynion gweithredol gyfyngu ymhellach ar fesurau gwella felly sydd ar raddfa fechan. Hefyd, er bod mesurau ar safle'n gallu cynyddu bioamrywiaeth leol, efallai na fydd y mesurau'n unol â phrosesau naturiol; er enghraifft, drwy greu swbstrad caled mewn ardaloedd sy'n bennaf yn waddodol neu greu nodweddion ar raddfa nad yw'n ecolegol ystyrlon. Efallai na fydd ymyriadau felly'n cyfrannu at gydnerthedd ecosystemau morol nac yn mynd i'r afael â phwysau ac effeithiau lleol/rhanbarthol allweddol sy'n effeithio ar yr amgylchedd morol.

Mae gwelliannau oddi ar safle yn tueddu i fod yn fwy amrywiol a hyblyg, gan gynnwys trin yn uniongyrchol/creu cynefinoedd naturiol ar wahanol raddfeydd a lefelau cymhlethdod. Yn ogystal, nid oes rhaid i welliannau oddi ar safle fod yn berthnasol o reidrwydd i'r cynefin(oedd) sy'n bresennol ar y safle datblygu, ond yn hytrach gellir eu defnyddio i wella cynefin arall neu adfer adnodd sy'n brin yn lleol (e.e. drwy ardollau neu gyllid uniongyrchol). Fel hyn, gellid hefyd mabwysiadu mentrau mwy strategol (ar raddfa ranbarthol) i gynnal ac adfer bioamrywiaeth forol yn unol â phrosesau naturiol a blaenoriaethau lleol/rhanbarthol.

Wrth ddatblygu egwyddorion ar gyfer gweithredu'r polisi drafft ar 'ecosystemau morol cydnerth' yn gymesur, mae'n bwysig felly ystyried pa mor bell i fynd ar drywydd gwelliannau 'o fewn prosiect' neu annog gweithgarwch gwella ehangach mewn cyd-destun ehangach o enillion net amgylcheddol. Mewn cyferbyniad ag ecosystemau daearol, mae systemau morol yn fwy agored a dynamig, a phrosesau ecosystem ar y cyfan yn gweithio dros ofod llawer mwy ac amrywiaeth o raddfeydd tymhorol. Felly, mae egwyddor 'gweithio gyda phrosesau naturiol'/'atebion seiliedig ar natur' yn benodol o bwysig wrth ystyried cydnerthedd ecosystemau morol. Bydd ymyriadau sy'n gweithio gyda phrosesau naturiol yn gynhenid yn fwy cydnerth na mathau eraill. Mae egwyddorion sy'n berthnasol i raddfa, cysondeb a chymesuredd hefyd yn debygol o fod yn benodol o berthnasol yng nghyd-destun gweithredu polisi ENV\_01. Efallai hefyd y bydd angen ystyried ymhellach sail statudol polisi gwella amgylcheddol yn y cyd-destun hwn.

# 1 Executive Summary

In 2017, the Welsh Government published the first draft Welsh National Marine Plan (dWNMP) (Welsh Government, 2017). Once adopted, Natural Resources Wales (NRW) will have a key role in supporting the implementation of the plan, through its regulatory (marine licensing and permitting regimes) and advisory functions.

The dWNMP contains a draft policy entitled ‘resilient marine ecosystems’ (numbered as ENV\_01). This policy states that: *‘Proposals should demonstrate how they contribute to the protection, restoration and/or enhancement of marine ecosystems’*.

NRW has commissioned ABPmer to carry out a desk-based study to help them better understand and explore options for the implementation of the ‘enhancement’ aspect of this policy. This was achieved by exploring the legislative and policy context of the ‘enhancement’ topic, as well as reviewing potential opportunities/techniques which could be employed by the different sectors which tend to apply for marine licenses in Wales. Principles which may be applied were also investigated.

For the purpose of this study, ‘enhancement’ was interpreted according to the following definition: *‘An environmental improvement that may intensify or increase the quality, value or extent of a resource’*. Furthermore, a developer should undertake such improvements in addition to those that might be required to meet a legal standard (i.e. go over and above any avoidance, mitigation and compensation measures required by law). This is a relatively restricted interpretation of the enhancement concept, as the term is also often used to describe any measure undertaken to support wider restoration or compensation efforts. As such, the definition of ‘enhancement’ applied for this study is closely related to the so-called ‘net gain’ concept, which is generally understood to be a development that leaves the environment or biodiversity in a better state than before.

The context review has demonstrated that there is a wide variety of relevant legislation and policy which refers to environmental measures related to the enhancement concept, be it in its wider or more restricted sense. Furthermore, while there is a lot of aspiration to deliver ecological enhancement in the marine environment, there are limited practical examples, avenues for enforcing such actions, or indeed guidance for undertaking/choosing specific measures. This is in contrast to measures which have to be legally undertaken to avoid/minimise (mitigate) and/or compensate for impacts on most nationally and internationally designated sites, such as Natura 2000 sites. As the majority of the Welsh (and wider UK) coastline is already highly designated, there is a considerable body of experience relating to mitigation and compensation measures in the marine environment, and established means of enforcing such actions through existing legislation. Also, the fact that Natura 2000 site compensatory schemes are often designed with the application of project-specific multipliers to account for factors such as uncertainty and distance, goes some way towards explaining why ‘net gain’ type enhancements are not generally undertaken during UK marine developments.

A wide range of examples of environmental enhancement measures has been identified through the literature review. This includes both onsite and offsite measures.

Onsite enhancement initiatives typically involve introducing objects or modifying artificial coastal structures to increase their complexity and/or the roughness of their surfaces. This has become known as 'greening the grey', and is based on the ecological premise that biodiversity is inherently greater where an environment includes multiple microhabitats, niches and refuges against predators and environmental stresses. Aside from modifying structures, a raft of other measures is also conceivable for onsite enhancement, including habitat creation through managed realignment (for which there is a large amount of UK experience) and improving conditions for animals such as breeding and roosting birds.

Introducing structural complexity into design can be valuable for enhancing local biodiversity. For example, armour and seawall enhancements have normally been found to improve local biodiversity within 6 to 12 months of deployment relative to business-as-usual approaches. However, onsite environmental enhancement tends to be undertaken at very local scales and can take the form of 'environmental gardening'. This scale of intervention (often seen as research) can be less relevant in the wider marine environment (in contrast to terrestrial developments). This may particularly be the case where marine infrastructure has an operational function (e.g. quay walls, offshore foundations etc.), as such small-scale enhancement measures may be further limited by operational requirements. Furthermore, while onsite measures may increase local biodiversity, the measures may not be in line with natural processes; for example, by creating hard substrate in areas that are predominantly sedimentary or creating features at a scale that is not ecologically meaningful. Such interventions may not contribute to the resilience of marine ecosystems nor address key local/regional pressures and impacts affecting the marine environment.

Offsite enhancements tend to be more wide ranging and flexible, including direct manipulation/creation of natural habitats at different scales and levels of complexity. In addition, offsite enhancements do not necessarily have to be related to the habitat(s) present at the development site, but instead can be used to enhance alternative habitat or restore a locally scarce resource (e.g. through levies or direct funding). This could also enable the adoption of more strategic (regional scale) initiatives to maintain and restore marine biodiversity in line with natural processes and local/regional priorities.

In developing principles for proportionate implementation of the draft policy on 'resilient marine ecosystems', it is therefore important to consider how far to pursue 'within project' enhancements or to encourage broader enhancement activity within a wider context of environmental net gain. In contrast to terrestrial ecosystems, marine systems are more open and dynamic, with ecosystem processes generally working over much larger spatial and a range of temporal scales. Thus, the principle of 'working with natural processes'/'nature-based solutions' is particularly important when considering the resilience of marine ecosystems. Interventions that work with natural processes will inherently be more resilient than other types. Principles related to scale, consistency and proportionality are also likely to be particularly pertinent in the context of implementing policy ENV\_01. Further consideration may also need to be given to the statutory underpinning of an environmental enhancement policy in this context.

## 2 Introduction

### 2.1 Background

In 2017, the Welsh Government published the first draft Welsh National Marine Plan (dWNMP) (Welsh Government, 2017). Consultation on the dWNMP closed in March 2018, and the publication of the final plan is anticipated in 2019. Once adopted, Natural Resources Wales (NRW) will have a key role in supporting the implementation of the plan, through its regulatory (marine licensing and permitting regimes) and advisory functions.

NRW commissioned ABPmer to undertake a study to help them better understand and explore options for the implementation of draft plan policy ENV\_01 ('resilient marine ecosystems') as part of the dWNMP. This policy states that:

*'Proposals should demonstrate how they contribute to the protection, restoration and/or enhancement of marine ecosystems'.*

Specifically, ABPmer has been asked to focus on the 'enhancement' aspect of draft policy ENV\_01.

The following clarifying paragraphs contained in the draft implementation guidance of the dWNMP are also worth highlighting in relation to 'enhancement' (with bold highlights added by ABPmer for this report):

*'213. Policy ENV\_01 ensures that **biological and geological** components of ecosystems are maintained, restored where needed and **enhanced** where possible, to **increase the resilience** of marine ecosystems and the benefits they provide. [...]*

*215. Particular focus should be given to the **habitats and species of principal importance** for the purpose of maintaining and enhancing biodiversity in Wales listed under Section 7 of the Environment (Wales) Act. [...]*

*218. Through finding **new and innovative ways** to restore and **enhance biodiversity**, proposals can help build resilience in our marine ecosystem to ensure we continue to receive the benefits they provide in the long term.*

*219. Incorporating restoration and/or **enhancement** of marine ecosystems into proposals **doesn't have to be expensive or complex**. It could include using different substrates for building on the foreshore that are favourable to post-construction colonisation by a range of species. Small changes to intertidal structures that allow the formation of crevices in walls or pools at low tide as opposed to the structure drying out entirely can provide an additional environment for rock pool species that would otherwise be unable to exist there.*

*220. **Not all proposals can include** an element of restoration or **enhancement**. Early engagement with NRW is recommended to discuss possible opportunities and design solutions.'*

### 2.2 Objectives

For this study, NRW commissioned ABPmer to undertake a desk-based review to help inform future practice and guidance with regard to enhancing marine and coastal ecosystems in the context of licensable marine activities.

There is already substantial experience, expertise and guidance in relation to ensuring the protection and maintenance of biodiversity and ecosystems within current decision-making processes. There is less consistent practice and advice in terms of the enhancement of marine ecosystems, particularly in the context of the range of potential activities that occur in the marine/coastal area. This project therefore seeks to explore the extent to which the biological and geological components of ecosystems can be enhanced in the process of undertaking licensable activities in the marine area.

As such, the specific aims of the project were as follows:

- To identify existing relevant literature, legislation, policy and practice to support the implementation of ecosystem resilience in the context of licensable marine activities;
- To review potential opportunities for enhancing ecosystem resilience for key sectors; including outlining current practice/ guides, the potential to incorporate ecological enhancements within each sector and to consider potential costs of undertaking such restoration/enhancement; and
- To assess the relevant existing information on enhancement of marine ecosystems through licensable activities and support the production of NRW guidance supporting implementation of the policy.

## 2.3 Methodology

A desk-based review has been undertaken to explore the concept of ecosystem enhancement to support the increased resilience of marine ecosystems through licensable activities in the marine environment in the context of dWNMP policy ENV\_01. This review focussed on reviewing the highlighted and other notable literature, drawing on the collective knowledge of ABPmer staff, and also contacting practitioners for further information.

The report has been structured according to the key objectives of this study; as follows:

- Section 3:** Context review;
- Section 4:** Review of ecological enhancement opportunities;
- Section 5:** Review of principles which could be applied; and
- Section 6:** Conclusions and recommendations.

## 3 Context Review

This Section is structured as follows. Definitions are firstly provided in Section 3.1. Relevant legislation, policy and guidance are then reviewed in Section 3.2. The key findings of the context review are discussed in Section 3.3.

### 3.1 Definitions

#### 3.1.1 Enhancement

As noted in its ‘guidance on terminology relating to environmental measures in the context of marine developments’ (NRW, 2018), NRW interprets enhancement as:

*‘An environmental improvement that may intensify or increase the quality, value or extent of a resource.’*

Furthermore, NRW has advised that, for the purpose of this project, enhancement should be interpreted as defining measures that a developer may wish to undertake in addition to those that might be required to meet a legal standard. Thus, for the purpose of this project, ecological enhancement measures are understood to be those that actually improve the ecological condition of the development site (or an alternative site), and go over and above any avoidance, mitigation and compensation measures. Definitions for related measures/terms are provided below in Section 3.1.2.

#### 3.1.2 Related measures/terms

NRW (2018) also provided definitions for measures which can be considered to be related to ‘enhancement’, many of which are used in connection with addressing potential or actual negative environmental impacts of development proposals:

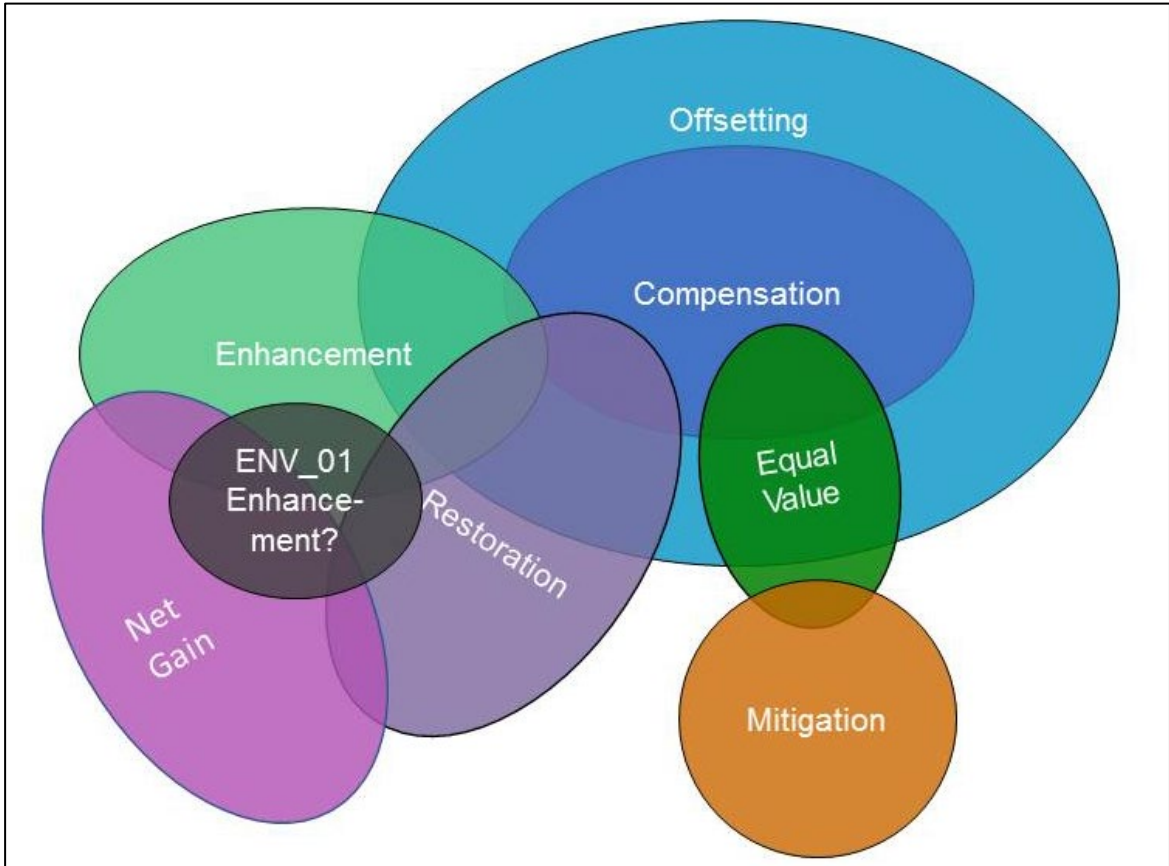
- **Mitigation:** *A measure to avoid, reduce, minimise or cancel out one or more adverse impacts;*
- **Compensation:** *A measure to make up for the negative effects of a plan or project. The term should only be used appropriately in the context of the different legislation requirements (as described in Section 3.2) when referring to specific measures;*
- **Offsetting:** *Any measure implemented to counteract a negative effect;*
- **Restoration:** *To return an environmental resource, for example a habitat, species, waterbody or landscape feature, to a former known and preferred condition or state;*
- **Equivalent Value:** *A measure that seeks to compensate for an adverse effect on a Natura 2000 feature by creating or improving a feature that makes a different contribution to the coherence of the Natura 2000 network to that being damaged or lost. If equal value measures are under consideration for a particular plan or project, NRW strongly advise that legal advice is sought.*

Other related measures/definitions not included in NRW’s (2018) terminology guidance are also relevant to this study, notably net gain. **Net gain** is generally understood to be a development that leaves the environment or biodiversity ‘in a better state than before’ (e.g. CIEEM, 2016).

3.1.3 Summary

As noted in NRW (2018), ‘terminology describing environmental measures often has similar meanings. However, it is important to be clear when and which measures under discussion are specifically required under certain legislation, particularly the Habitats Directive.’

In its widest sense, enhancement can be interpreted as a measure undertaken to support compensatory or mitigation measures required by law, for example where there is (potential) damage/loss of a key feature of a European designated/Natura 2000 site. However, as noted in Section 3.1.1, for the purpose of this study, ‘enhancement’ is to be interpreted as being over and above such requirements. This interpretation of enhancement is closely related to the concept of net gain, the UK context of which is further elaborated upon in Section 3.2.3. The diagram included below as Figure 1 seeks to illustrate the relationships between the terms/measures introduced in this Section.



Source: Created by ABPmer for this report

Figure 1. Diagram to define the overlap in terminology relating to environmental measures

## 3.2 Legislation, Policy and Guidance

### 3.2.1 Introduction

The range of environmental measures undertaken as part of a development is typically derived by undertaking formal assessments, chiefly Habitats Regulations Assessments (HRA), Environmental Impact Assessments (EIA) and/or Water Framework Directive (WFD) compliance assessments. These assessments are driven by various pieces of legislation (which are further outlined in Section 3.2.2). Normally, the required/desired environmental measures are reflected in the determination of a permission; for example, a Development Consent Order (DCO)<sup>1</sup>, Marine Licence<sup>2</sup> or Welsh Development of National Significance<sup>3</sup> and the associated conditions and requirements. Other measures may be requested on an advisory or voluntary basis only, and are currently unlikely to be a compulsory part of a consent or licence condition.

However, Welsh legislation, national policy and, increasingly, local planning policy, now point towards the enhancement of biodiversity and/or the environment as part of the development process.

This section reviews relevant existing literature, legislation, policy and practice for enhancing ecosystems in the context of licensable activities within the marine environment in Wales. Section 3.2.3 then elaborates upon wider UK/English context related to the Net Gain principle which does not directly apply to Wales, but from which parallels could possibly be drawn. Throughout, particular attention is paid to items related to 'enhancement' as defined for the purpose of this project. More detail on the discussed aspects is provided in Appendix A (Section 9).

### 3.2.2 Legislation, policy and guidance relevant to Wales

There is a wide range of legislation seeking to avoid, reduce and minimise environmental impacts, which tends to be driven by European legislation. This legislation is outlined first, before other Welsh policy or guidance documents more specifically mentioning 'enhancement' or 'net gain' are discussed.

#### **Key pieces of legislation, policy and guidance related to mitigation and compensation**

Table 1 lists the key pieces of environmental legislation related to mitigation and compensation of environmental impacts in the marine environment which are relevant to Wales.

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<sup>1</sup> Permission for Nationally Significant Infrastructure Projects (NSIP) under the Planning Act 2008, determined by the Secretary of State

<sup>2</sup> Permission for marine developments under Part 4 of the Marine and Coastal Access Act 2009, determined by NRW in Wales

<sup>3</sup> Permission for certain Welsh projects considered to be Developments of National Significance under the Planning (Wales) Act 2015.



Table 1. Key pieces of legislation related to mitigation/compensation relevant to Wales

EU Directive (where applicable)	Legislation relevant to Wales	Detail/designation (coastal/marine)
EIA Directives (85/337/EEC as amended; 2014/52/EU)	Marine Works (EIA) Regulations 2007 (as amended) (re. marine licensing)	Sets out what development require EIA, and how this should be undertaken.
Water Framework Directive (WFD) (2000/60/EC)	Water Environment (WFD) (England and Wales) Regulations 2017	Transitional and coastal waterbodies, with objective to achieve “good ecological and good chemical status”.
Marine Strategy Framework Directive (MSFD) (2008/56/EC)	Marine Strategy Regulations 2010	Coastal and marine waters, with objective to achieve ‘good environmental status’
The Birds and Habitats Directives (2009/147/EC; 92/43/EEC)	Conservation of Habitats and Species Regulations 2017 (the “Habitats Regulations”) (as amended)	Natura 2000 sites: Special Protection Areas (SPAs) and Special Areas of Conservation (SACs); key objective is to maintain or restore these to a favourable conservation status. European Protected Species.
Bern Convention and Council Directive 79/409/EEC on the conservation of wild birds	The Wildlife and Countryside Act 1981 (WACA) (as amended)	Underpins Sites of Special Scientific Interest (SSSI) designations and protection of nationally protected species.
n/a	Marine and Coastal Access Act 2009	Marine Conservation Zones (MCZs) in English and Welsh waters, and UK offshore waters.

Whilst none of the pieces of legislation listed in Table 1 specifically mention ‘enhancement’, many of the techniques employed to mitigate and/or compensate for developments which might negatively impact sites, species or waterbodies designated under these pieces of legislation, could also conceivably be employed to promote enhancement (see Section 4). Furthermore, knowledge transfer is also conceivable with regard to measures in place to help the bodies responsible for looking after these sites improve the condition of such sites.

With regard to mitigation, such measures can be sought at any stage of the design of a given development, often informed by assessments such as EIA, HRA and WFD compliance assessments.

### The Habitats Regulations

The Habitats Directive does not expressly use the terms ‘mitigate’ or ‘mitigation’. However, the concept of mitigation is implicit in the HRA process, which refers to measures that are introduced to avoid or reduce a harmful effects on a European site. In carrying out Appropriate Assessments, Competent Authorities must consider whether they can satisfactorily conclude that such measures incorporated into a plan or project, or secured through conditions, will enable it to be concluded that the plan or project will not have an adverse effect on the integrity of a Natura 2000 site.

‘Compensatory measures’ is a key term used in Article 6(4) of the Habitats Directive and in the Conservation of Habitats and Species Regulations (2017). It describes measures taken to ensure that the overall coherence of the Natura 2000 network is protected. Compensatory measures are required once a competent authority has

concluded that adverse effects on a Natura 2000 site cannot be ruled out, and where the 'Imperative Reasons of Overriding Public Interest' (IROPI) and 'no alternative solutions' tests have been met<sup>4</sup>.

Compensatory measures are defined by EC Habitats Directive guidance as independent of a plan or project; they are intended to compensate for any negative effects. In the UK, compensation is generally interpreted as having to correspond precisely to the negative effects on the species or habitat concerned. This has in practice led to the adoption of a 'like-for-like' principle with regard to habitats in particular, often with the application of project-specific multipliers to account for factors such as uncertainty and distance. Many managed realignment schemes have to date been motivated by the need to compensate for impacts to Natura 2000 sites (ABPmer, 2017a) (see also Section 4.2).

Whilst not directly related to mitigation or compensation, it is worth noting that the management of Natura 2000 sites is the responsibility of the devolved administrations, whose respective authorities would tend to put in place management plans for individual or sets of designated sites; these would amongst others include plans/suggestions for specific management and enhancement activities<sup>5</sup>.

For example, in Wales, an Action Plan has recently been published for the country's marine Natura 2000 sites (Marine Protected Area (MPA) Management Steering Group, 2018), which focuses on priority network level actions, but also includes some current local level actions. The latter incorporate some measures such as the reduction of disturbance to marine mammals or birds. This builds on work undertaken as part of a major project which ran from 2012 to 2015, that developed a strategic forward plan which sets out the requirements for the management and restoration of the Natura 2000 network of species, habitats and sites in Wales. The key outputs from this LIFE Natura 2000 Programme were (NRW, 2015a):

- Prioritised Improvement Plans (PIPs) for all Natura 2000 sites in Wales;
- Eleven Thematic Action Plans (TAPs);
- Five Cross-cutting Action Plans; and
- An updated Wales chapter of the UK Prioritised Action Framework.

The 'Theme Plans' recommend approaches to address significant issues which affect many Natura 2000 sites, and which would benefit from a strategic, rather than site-by-site approach. The following TAPs are particularly relevant in the marine context:

- Flood and coastal erosion risk management;
- Non-native invasive species and pathogens;
- Man-made changes to hydraulic conditions;
- Marine fisheries; and
- Marine litter.

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<sup>4</sup> See also <http://www.assembly.wales/research%20documents/17-038/17-038-web-english.pdf>

<sup>5</sup> In addition to actions related to other activities, such as strategic planning, regulation, guidance and monitoring (see, for example, MPA Management Steering Group, 2018).

## **The Water Framework Directive**

For WFD derogations, there is a requirement for all practicable steps to be taken to mitigate adverse impacts to a body of water. The WFD does not require compensatory measures to be undertaken. However, WFD and Habitats Directive guidance<sup>6,7,8</sup> make clear distinctions between mitigation and compensatory measures. As such, the WFD interpretation of ‘compensation’ broadly aligns with the Habitats Regulations definition of ‘compensatory measures’.

It is worth noting that the WFD also sets out specific ‘mitigation’ measures for each heavily modified water body. These measures are to mitigate impacts that have been, or are being caused by human activity. They aim to enhance and restore the quality of the existing environment and could be, and have been, employed by developers when unavoidable impacts are expected. Enhancement related WFD mitigation examples include realigning flood defences, enhancing ecology and improving fish passage (e.g. NRW, 2015b).

## **Marine Conservation Zones (MCZs)**

There is specific legislation in place for offsetting negative effects of plans or projects in MCZs (S126 (subsection 7c) Marine and Coastal Access Act). With regard to these national designations, ‘measures of equivalent environmental benefit to the damage’ need to be undertaken if it is considered that the benefit to the public of proceeding with the act clearly outweighs the risk of damage to the environment that will be created by proceeding with it. In England, the Marine Management Organisation (MMO, 2013) considered that ‘*types of compensatory measures that might be considered under the Habitats Directive would also be appropriate to put forward here, although consideration will not be confined to those*’. There is currently only one MCZ designated in Welsh waters (Skomer Marine Conservation Zone) and therefore currently no detailed Welsh guidance. However, Welsh Government are initiating work to designate further MCZs, beginning in 2019.

## **UK Marine Policy Statement 2011**

With regard to the marine context, the UK Marine Policy Statement 2011, which is applicable in Wales is also worth noting. This stated as one of its high level marine objectives that biodiversity should be ‘*protected, conserved and where appropriate recovered and loss [...] halted*’. It furthermore elaborates that:

*‘Marine plan authorities should be mindful that, consistent with the high level marine objectives, the UK aims to ensure:*

- *A halting and, if possible, a reversal of biodiversity loss with species and habitats operating as a part of healthy, functioning ecosystems; and*

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<sup>6</sup> Common Implementation Strategy for the Water Framework Directive (2000/60/EC) (2009). Guidance Document No. 20. Guidance Document on Exemptions to the Environmental Objectives.

<sup>7</sup> Common Implementation Strategy for the Water Framework Directive (2000/60/EC) (2009). Guidance Document No.35. Exemptions to the Environmental Objectives according to Article 4(7).

<sup>8</sup> Managing Natura 2000 Sites. The Provisions of Article 6 of the Habitats Directive (92/43/CEE) (2000).

- *The general acceptance of biodiversity's essential role in enhancing the quality of life, with its conservation becoming a natural consideration in all relevant public, private and non-governmental decisions and policies.'*

## Welsh legislation, policy and guidance

### **Well-being of Future Generations (Wales) Act 2015**

The Well-being of Future Generations (Wales) Act 2015 seeks to improve the social, economic, environmental and cultural well-being of Wales. Under the 'Resilient Wales' goal, it aims to create *'a nation which maintains and **enhances** a biodiverse natural environment with healthy functioning ecosystems that support social, economic and ecological resilience and the capacity to adapt to change (for example climate change).'*

### **Environment (Wales) Act 2016**

The Environment (Wales) Act 2016 sets out the requirement for the 'sustainable management of natural resources'. Sections 3, 4, 6 and 7 of the Act are the key sections which are of relevance to 'enhancement'. Section 3 on the 'Sustainable management of natural resources' notes that objective is to

*'maintain and **enhance** the resilience of ecosystems and the benefits they provide and, in so doing—*

*(a) meet the needs of present generations of people without compromising the ability of future generations to meet their needs, and*

*(b) contribute to the achievement of the well-being goals in section 4 of the Well-being of Future Generations (Wales) Act 2015 (anaw 2).'*

Section 4 sets out principles for the sustainable management of natural resources (these are outlined in Section 5.4 of this report). Section 6 of the Act requires public authorities to seek to *'maintain and **enhance** biodiversity [...] in the exercise of their functions'*. Section 7 additionally requires Welsh Ministers to publish a list of living organisms and habitats in Wales, which are considered of key significance to sustain and improve biodiversity in relation to Wales Section 7 of the Act. The Act also notes that the Welsh Ministers must *'take all reasonable steps to maintain and **enhance** the living organisms and types of habitat included in any list published under this section and encourage others to take such steps'*. Marine and coastal species and habitats have been extracted from the lists available on the Wales Biodiversity Partnership Website, and are listed in Appendix B (Section 10).

### **The 2015 Nature Recovery Action Plan for Wales**

Welsh Government published the national biodiversity strategy 'The Nature Recovery Action Plan for Wales' in 2015, with the ambition to *'halt the decline in biodiversity by 2020 and then reverse the decline, for its intrinsic value, and to ensure lasting benefits to society'*. The Plan sets out how Wales will deliver the commitments of the UN convention on biological diversity, the strategic plan for biodiversity 2011-2020 and the 20 associated Aichi targets (a short term framework for action), as well as the EU biodiversity strategy. The Plan focusses on six objectives for nature recovery in Wales, and actions to reverse the decline of biodiversity are set out under each objective. The objectives are as follows:

- Objective 1: Engage and support participation and understanding to embed biodiversity throughout decision making at all levels.
- Objective 2: Safeguard species and habitats of principal importance and improve their management.
- Objective 3: Increase the resilience of our natural environment by restoring degraded habitats and habitat creation.
- Objective 4: Tackle key pressures on species and habitats.
- Objective 5: Improve our evidence, understanding and monitoring.
- Objective 6: Put in place a framework of governance and support for delivery.

The actions are allocated to specific partners, including public bodies and local nature partnerships. Public bodies are required to consider using the Plan as a basis on which to base a 'biodiversity and ecosystem resilience duty forward plan'.

### **Planning (Wales) Act 2015**

The Planning (Wales) Act 2015 provides a high-level framework for achieving sustainable development and land use in Wales; though there is no specific mention of 'enhancement' within the Act.

### **Planning Policy Wales**

Welsh terrestrial planning policy is outlined in the Planning Policy Wales (PPW), which was first published in 2016. The primary objective of PPW is *'to ensure that the planning system contributes towards the delivery of sustainable development and improves the social, economic, environmental and cultural wellbeing of Wales, as required by the Planning (Wales) Act 2015, the Well-being of Future Generations (Wales) Act 2015 and other key legislation'* (Welsh Government, 2018). PPW includes specific policies on conserving and enhancing the natural environment through planning. It states that the planning system should contribute to the delivery of sustainable development and improve the social, economic, environmental and cultural well-being of Wales. The PPW and the associated National Development Framework (NDF) concentrate on development and land use issues of national significance, indicating areas of major opportunities and change, highlighting areas that need protecting and enhancing and helping to co-ordinate the delivery of Welsh Government. As part of the planning policy *'natural, historic and cultural assets must be protected, promoted, conserved and **enhanced**. Negative environmental impacts should be avoided [...]*. Furthermore, paragraph 6.4.3 of the PPW clarifies that *'the planning system has a key role to play in helping to reverse the decline in biodiversity and increasing the resilience of ecosystems, at various scales, by ensuring appropriate mechanisms are in place to both protect against loss and to secure **enhancement**.'* It is also noted in the same paragraph that development proposals must (amongst others) consider the need to *'secure **enhancement** of and improvements to ecosystem resilience by improving diversity, condition, extent and connectivity of ecological networks.'*

### **Technical Advice Notes**

Welsh supplementary planning advice is set out in the Government's Technical Advice Notes (TANs). Notably, **TAN 5** (Welsh Government, 2009) refers to offsetting, stating that *'where harm is unavoidable it should be minimised by mitigation measures and offset as far as possible by compensation measures designed to*

*ensure there is no reduction in the overall nature conservation value of the area or feature’.*

### **Town and Country Planning Act 1990**

In contrast to marine developments, in terrestrial planning, there exists a mechanism for securing planning gain under Section 106 of the Town and Country Planning Act 1990 (as amended), in the form of **s106 agreements**. S106 agreements routinely require developments to provide enhancements; these are often referred to as 'developer contributions'. In Wales, the Welsh Office Circular 13/97: Planning Obligations, sets out the Welsh Government's policy for the use of **planning obligations** (Welsh Office, 1997). When used properly, planning obligations can enhance the quality of development and enable proposals to go ahead which might otherwise be refused. While there is currently no formal policy of net-gain type enhancements within terrestrial planning in Wales, s106 agreements can and have been used to contribute to ecological enhancement. However, such agreements are in practice generally used by local authorities to deliver other types of benefit (including economic and social public benefit, e.g. road improvements).

### **Marine Planning**

With regard to marine planning in Wales, as noted above, this study is in support of a specific dWNMP policy, policy ENV\_01, which seeks to (amongst others) support **enhancement** through licensable activities. Please refer to Section 2.1 for enhancement-related references within the dWNMP.

### **3.2.3 Defra Net Gain context**

As noted in Section 3.1.1, the term 'enhancement' can be used in a relatively closely defined sense, whereby it only applies to measures which are undertaken in addition to mitigation/compensation measures, or in more general terms, whereby it describes environmental improvement, intensification or increase in quality, value or extent from an agreed baseline condition. In its more restricted sense, enhancement as defined for this study is closely related to the 'net gain' concept, for which there is currently significant policy interest in England (overseen by Defra).

Environmental Net Gain (ENG) was proposed in the UK Government's **25 Year Environment Plan** (Defra and HM Government, 2018) as a development to the increasingly established Biodiversity Net Gain (BNG). The Plan committed to embed ENG for development in England '*to deliver environmental improvements locally and nationally*'. It further specified that '*in future, we want to expand the net gain approaches used for biodiversity to include wider natural capital benefits, such as flood protection, recreation and improved water and air quality. Those approaches will sit alongside existing regulations that protect our most threatened or valuable habitats and species*'. Marine commitments were also included in the 25 Year Plan, though these did not mention 'net gain', instead pledging to '*reverse the loss of marine biodiversity and, where practicable, restoring it*'.

The 25 Year Environment Plan was at least in part prompted by the **Natural Capital Committee's (NCC's) annual reports**. Specifically, the 2015 Annual Report urged the UK Government to develop a 25-year plan for improving the natural environment and restoring its capital. In its 2017 Annual Report, the NCC emphasised the

importance of rapid progress in developing and delivering this plan if the Government's aims of this being the first generation to leave the environment in a better state than the one it inherited were to be met against a backdrop of falling stocks of national natural capital (NCC, 2018).

It is worth noting that, in December 2018, Defra launched a consultation on embedding an ENG approach in the planning system in England, including on whether or not (and how) BNG should be made mandatory<sup>9</sup>. Welsh Government has not launched a similar consultation in Wales.

The development of BNG in England essentially started with **Defra's biodiversity offsetting pilots** in 2012. These were in turn prompted by policy developments such as the **Natural Environment White Paper 2011** (HM Government, 2011), which contained a commitment to move '*to a net gain in the value of nature*'.

### 3.3 Summary

There is a wide variety of relevant legislation and policy which refer to environmental measures related to the enhancement concept, be it in its wider or more restricted sense as outlined in Section 3.1. Table 2 below provides a matrix of the key terms introduced in Section 3.1 in relation to key legislation and policy applicable in Wales.

This context review has further demonstrated that, while there is a lot of aspiration to deliver ecological enhancement in the marine environment, there is limited statutory underpinning of, and guidance related to, this aspiration at present.

Whilst impacts to most nationally and internationally designated sites require mitigation and compensation, there are limited statutory mechanisms that facilitate the adoption of enhancement activities for licensable activities in the marine environment. This is perhaps not surprising as the majority of the Welsh (and wider UK) coastline is already highly designated. As noted above, Natura-2000 site compensatory schemes are often designed with the application of project-specific multipliers to account for factors such as uncertainty and distance (e.g. Morris *et al.*, 2016). Developers undertaking such compensatory measures may thus not be motivated to pursue further 'net gain'-type enhancements, without such measures being made mandatory for all development. Furthermore, in the marine licensing field, there is currently a lack of a clear delivery mechanism for the enforcement of enhancement measures, such as s106 agreements in the terrestrial environment.

Also, due to the prevalence of compensatory habitat creation in the marine context, there is currently very limited discussion in the UK and wider European literature with regard to offsetting, or net gain, in the marine environment which is not related to 'like for like' creation, and little discourse on the types of habitats which could/should preferentially be created. In addition, 'equal value' compensation could be considered as a potential alternative to measures designed to compensate for adverse effects on a 'like-for-like' basis. As noted in Section 3.1.2, an equal-value approach entails offsetting a defined loss through the addition or creation of something of a different,

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<sup>9</sup> <https://consult.defra.gov.uk/land-use/net-gain/> [last accessed in December 2018; consultation to close in February 2019.

even very different, ecological character. Therefore, an alternative option may be to finance the enhancement of a nearby site of nature conservation interest or even the creation of new habitats on other land of low current ecological value. However, to date, such equal value approaches are largely untested in practice and law and may not be considered to be compliant with the Habitats Directive. Such an approach could conceivably also be applied to net-gain type enhancements.

Furthermore, the terms 'restore' and 'restoration' are used to describe environmental improvements which intend to return a resource to some known former and preferable condition. Although they entail the objective of returning something to a defined former state, they do not imply achieving a legally defined standard. However, under the Habitats Directive 'restore' is used in association with meeting a particular standard, in that the aim is for habitats and species to be maintained at, or restored to, favourable conservation status.

Lastly, within the marine environment, ecological enhancement also needs to be considered in the wider context of marine ecosystems. In contrast to terrestrial ecosystems, marine systems are more open and dynamic with ecosystem processes generally working over much larger spatial and a range of temporal scales. This has driven the concept of 'Working with Natural Processes' (more commonly referred to in Wales as 'nature-based solutions'), particularly in the context of managing fluvial and coastal flood risk<sup>10</sup>. Such concepts are important when considering the resilience of marine ecosystems – interventions that work with natural processes will inherently be more resilient than other types of intervention. Please see Section 5 for a discussion of this, and other principles.

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<sup>10</sup> <https://www.gov.uk/government/publications/working-with-natural-processes-to-reduce-flood-risk>



Table 2. References to environmental measures in key legislation and policy applied in Wales

Legislation/ policy	Enhance/ enhancement	Mitigation	Compensation	Offset/ Offsetting	Restore/ restoration	Equal value
Conservation of Habitats & Species Regulations 2017	N	N	Y	N	Y	N
Wildlife & Countryside Act 1981 (as amended)	Y	N	N	N	Y	N
Environment (Wales) Act 2016	Y	N	N	N	N	N
Wellbeing and Future Generations (Wales) Act	Y	N	N	N	Y	N
Marine Works (EIA) Regulations 2007	N	N	N	Y	N	N
WFD Common Implementation Strategy. Guidance No 20 & 35	N	Y	Y	N	N	N
Planning Policy Wales	Y	Y	Y	Y	Y	N
Technical Advice Note No 5. Nature Conservation	Y	Y	Y	Y	Y	N
Overarching National Policy Statement for Energy Infrastructure (EN1)	Y	Y	Y	N	Y	N
National Policy Statement for Energy Infrastructure (EN3)	N	N	N	N	N	N

## 4 Review of Ecological Enhancement Opportunities

### 4.1 Introduction

This Section reviews the potential techniques for enhancing ecosystem resilience through coastal/marine licensable activities.

Enhancement activities undertaken by the following sectors were the key focus of this review:

- Coastal development (including defence works);
- Aggregates;
- Aquaculture;
- Defence;
- Dredging and disposal;
- Renewable energy;
- Oil and gas;
- Fisheries;
- Ports and Shipping;
- Subsea Cabling;
- Surface water and wastewater treatment; and
- Tourism and recreation.

A thorough literature review was undertaken to provide an overview of good practice and ecological enhancement opportunities. For each technique, ABPmer aimed to: outline current practice/guidance, referencing any existing relevant guidance, and consider the potential cost of undertaking such restoration/enhancement.

This Section provides a brief overview of possible enhancement measures in the marine environment. More detailed results are presented in Appendix C (Section 11). The Section is divided into onsite versus offsite enhancements, representing actions which could conceivably be suitable for incorporation within the proposed design for the local development site, versus those which are more likely to be suitable for application offsite (at an alternative site), recognising that the scope of off-site opportunities will be much broader.

The measures are grouped into categories related to the habitat and/or species group they relate to, and cost information is provided where available. The matrix provided in Section 4.4 summarises which measures have been, or could be, applied by the sectors listed above.

### 4.2 Onsite Enhancements

Onsite enhancement initiatives typically involve introducing objects or modifying artificial coastal structures to increase their complexity and/or the roughness of their surfaces. This has become known as 'greening the grey' or 'ecologically sensitive coastal infrastructure', and is based on the ecological premise that biodiversity is inherently greater where an environment includes substrata that provide multiple microhabitats, niches and refuges against predators and environmental stresses

(Naylor *et al.*, 2017a; Firth *et al.*, 2012; Martins *et al.*, 2015). Aside from modifying structures, a raft of other measures is also conceivable for onsite enhancement, including habitat creation and improving conditions for faunal features (e.g. by using locally sourced rock armour).

The type of enhancement that will work best for any given project will vary widely and will, amongst others, depend on the project's scale, its location, and the tidal height at which it is constructed. A range of onsite enhancements for both coastal and offshore development are discussed below. More in-depth case studies are presented in Appendix C (Section 11). The measures have been grouped into the following categories:

- Enhancement of existing artificial structures;
- Intertidal habitat creation/restoration;
- Fish and bird enhancements; and
- Other habitat modification measures.

#### 4.2.1 Enhancement of artificial structures

In this section, enhancement measures related to vertical structures are first discussed, before enhancement measures related to rock armouring and marine scour protection are outlined.

##### 4.2.1.1 Vertical structure enhancement

For projects where the development site contains existing hard structures such as seawalls or quay walls, or where the construction of new such structures forms part of the proposals, features can be introduced to enhance the surface roughness and to create pits and water-retaining features. Such features are implemented to facilitate greater diversity of organisms occupying the engineered habitats.

Examples can be categorised as follows:

- Retrofitting or including pocket rock pools onto vertical sea defences (e.g. 'vertipools');
- Increasing the surface roughness of structures by drilling holes or installing encasements/tiles.

#### **Retrofitting or including pocket rock pools**

Where seawalls are already installed, retrofit enhancement measures provide significant opportunities. 'Vertipools' are cast marine concrete units designed to be attached to sea defences to retain water as the tide recedes. They are shaped to replicate a range of natural microhabitats (e.g. rock pools) for shoreline species and are simply fixed with bolts or brackets and nontoxic waterproofing resin (Naylor *et al.*, 2017a).

A recent project example includes the installation of six vertipools at the Wightlink quay wall at Fishbourne. The vertipools were installed 2017 at different tidal heights between mean high and low water, designed to provide areas of standing water to

increase biodiversity across the site (see Figure 2 for an image showing five of these). These vertipools were included in the project to, amongst others, offset small scale non-designated mudflat losses due to piling (requested by the Environment Agency to achieve a no net loss of the mudflat priority habitat). Bournemouth University and ABPmer are monitoring these vertipools at Fishbourne, with over 30 species having been recorded from the array in its first year (ABPmer, 2018).



Source: ABPmer

Figure 2. 'Vertipools' at Fishbourne (Isle of Wight, England) (two months after installation)

Vertipools have also been installed at other locations in the UK, including Bouldner beach on the Isle of Wight and Edinburgh (Naylor *et al.*, 2017a). The ongoing EU-funded Ecostructures project is also utilising the vertipools produced by Artecology to trial the development of effective eco-engineering solutions to coastal structures. The first round of vertipools were installed at Kilmore Quay, Ireland, in November 2018, but more are to be installed around the Welsh and Irish coastlines as part of the project (Ecostructures, 2018).

Further afield, in Sydney Harbour, flowerpots were retrofitted to seawalls to introduce artificial rock pool structures to the seawall (Strain *et al.*, 2017). The cost of installation of such products is project specific and will depend on size, complexity and placement of the rock pool structures. Installation also requires some local and specialist knowledge (an understanding of site characteristics, ecology, substrate and fixings). Naylor *et al.* (2017a) quote a case study whereby the incorporation of 50 vertipools for 100 m of seawall was estimated to cost approximately £300 per m, or approximately £600 per vertipool. The creators of the Vertipools, Isle of Wight based company Artecology quote per-unit costs of between £175 and £500, excluding tax and installation (pers. comm., Artecology/ABPmer, January 2019). Installation costs can be highly variable, depending on the accessibility and nature of the installation site. For example, all-inclusive fees of £2,500 per unit have been incurred for a more bespoke (confidential) UK project. At Sydney Harbour (Australia), 80 custom-made 'flowerpots' were installed in 2015, at \$300 each (around £170 in 2018 prices) (see Section 11.1.1 for case study details).

Where new seawalls are being constructed, rock pools can be integrated into their design. For example, again in Sydney Harbour, artificial pools were created through the inclusion of small cavities in the in a vertical sandstone wall in 2009. Monitoring

determined that invertebrate species richness was increased after one year, with pool biodiversity greater than adjacent walls. Similar recessed areas were also included in the new walls constructed as part of the 2011 Sheldon and Ringmore tidal defence scheme in Devon (see Section 11.1.1 and Naylor *et al.*, 2011 for both the Sydney Harbour and Sheldon/ Ringmore case studies).

### Increasing the surface roughness of structures

Numerous techniques are conceivable to increase the surface roughness of coastal and marine structures, ranging from drilling (or including) holes, replacing mortar, to attaching tiles, ecoconcrete, and timber battens.

For example, at Sheldon (Devon), holes were drilled into parts of the seawall to create water retaining features (Figure 3). This was undertaken as part of the Urbane Project (ABPmer, 2017c).



Source: <http://urbaneproject.org/project>

Figure 3. Drilled sea wall at Sheldon (Devon, England) – inset shows limpets and red and green algae occupying one of the drilled pits

Additionally, vertical structures can be enhanced by attaching items to them. For example, EConcrete® have produced a range of modular sea wall elements which can be attached to existing vertical structures, and which have been shown to support the growth of marine communities by modifying the surface texture (see Figure 4). In the UK, Moore Concrete Products Ltd are the exclusive manufacturer for EConcrete® products; the seawall tiles retail at around £350 per square metre (excluding tax/installation) (pers. comm. Moore Concrete Products Ltd/ABPmer, February 2019). In addition, EConcrete® uses a bio-enhance concrete mix as an alternative product to concrete. The mix ‘provides suitable biological and environmental conditions for the development of a rich and diverse assemblage of marine flora and fauna’ (EConcrete®, 2018).



Source: ECOConcrete®, 2018

Figure 4. ECOConcrete® sea wall tile deployed at Herzliya Marina, Mediterranean Sea (Israel)

For a similar project undertaken to repair sea defences in Hartlepool to cost of adding bio-enhanced, textured panels cost approximately £8-30 more per m<sup>2</sup> than plain-cast panels (Naylor *et al.*, 2017a). Similar tile attachment projects have been trialled/studied in numerous locations across the world, and have generally been found to be beneficial, when compared to the alternative, unenhanced, artificial structure (Evans *et al.*, 2019).

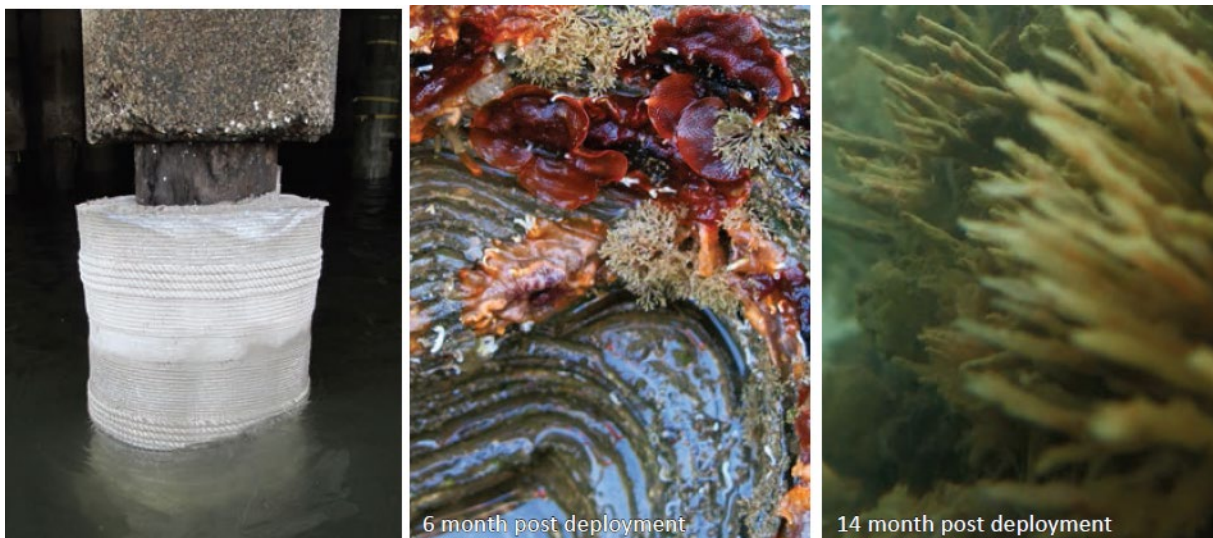
As part of the EU-funded Ecostructures project, a range of pre-fabricated ecologically engineered tile enhancement units are being trialled as a method of creating ecologically sensitive infrastructure. Nine different concrete designs which vary in binder composition, aggregate type, texture and colour are being trailed to assess how best to enhance artificial structures. Tiles have been deployed on the breakwater at Mornington, Meath, Ireland (Figure 5). Results are yet to be published, but tiles are expected to be removed in April 2019 (Natanzi and McNally, 2018).



Source: Ecostructure Website Photo Gallery [last accessed May 2019]

Figure 5. Alternative concrete tile being fitted at Mornington, Meath (Ireland) as part of the Ecostructures project

Pile encapsulation is another form of surface enhancement. Pile structures can be enhanced using concrete encasements which increases the heterogeneity of the pile structure and increased the availability of substrate capable of supporting marine communities. Pile encasements have for example been used as part of the Brooklyn Bridge Park project, New York, in 2013 (see Figure 6). Encasements resulted in between 70-100% live cover and displayed higher biodiversity compares to control pile structures (ECONcrete, 2018), including coverage of barnacles, sessile polychaetes, sponges and bivalves. Crabs were also spotted mating on the bio-enhanced piles indicating the addition of valuable spawning grounds.



Source: ECONcrete®, 2018

Figure 6. ECONcrete® pile encapsulation in New York (US)

A further pertinent study was undertaken in the Mediterranean looking to improve the complexity of vertical timber pile wharfs. Artificial seagrass modules, inspired by seagrass meadows, were developed to improve nursery functions for fish. Modules were attached to pile wharfs to provide shelter for juvenile fish. The micro-habitat's complexification of the port infrastructure was associated with positive effects both on species richness and densities of juvenile stages of fish in comparison to non-equipped port infrastructures studied as control sites (Lapinski *et al.*, 2017).

It should be noted that any enhancement undertaken during coastal infrastructure development should not interfere or inhibit the technical function of the structure or impact on structural integrity.

#### 4.2.1.2 Rock armour enhancement

Enhancements can be undertaken to either retrofit existing rock armour to increase interest/ diversity or include relevant structures during the installation of new rock armour. When using rock armour, locally sourced rock or rock of a comparable type will allow similar communities to develop to those on adjacent rocky shores.

Rock armouring units are modular blocks which are used to provide coastal defence against hydrodynamic forces. As a method of increasing biodiversity of these structures, ecological units such as bio-blocks can be used to enhance the heterogeneity of the environment and increasing biodiversity. For example, pre-cast 'Bioblock' developed by Plymouth University were implemented as part of a development at Colwyn Bay in Wales in 2012 (see Figure 7). One 6-tonne pre-cast concrete cube with dimensions of 1.5 x 1.5 x 1.1 m was introduced to the rock armouring. During the casting process a variety of micro-habitat features were introduced, including rock pools and crevices varying diameters, depths and alignments. Monitoring of the 'Bioblocks' found they consistently supported greater species richness than adjacent boulders. Functional groups represented on the feature included algae, barnacles, shrimps, annelids, crabs, ctenophores and gastropods whilst those represented on the adjacent boulders included algae, barnacles and crabs (Firth *et al.*, 2014).

Per-unit Bioblock cost approximately £2,000 for the mould, casting, transport and deployment of the prototype, which is equivalent to £800/m<sup>3</sup>. This compares to between £63 – 93/m<sup>3</sup> for rock groynes. The bioblock is between 9 – 13 times more expensive per unit compared to business as usual rock armour units used in rock groynes (Naylor *et al.*, 2017a). Mass production of Bioblocks would reduce their costs. Similar products have been developed elsewhere, for example, EConcrete® sells similar 'armouring units'. These retail at £850 per unit (1.2 m cube) (excluding tax/installation) (pers. comm. Moore Concrete Products Ltd/ABPmer, February 2019). It is worth noting that the latter company also sells larger artificial tide pools which 'can be integrated into riprap, revetment and breakwater zones and are designed to be easily installed by standard landscaping techniques'; these are £990 per unit (see Section 11.1.2 for case study).





Source: Urbane Project Website [last accessed March 2019]

Figure 7. Bioblock positioned within rock armouring at Colwyn Bay (Conwy)

Another method of enhancing rock armouring is using core-drilling to increase heterogeneity of the structure. When rock armour breakwaters were put in place at Tywyn in Cardigan Bay in October 2011, artificial pools were created in the rock using core drills. These were monitored over the course of the project and were found to support greater species richness than adjacent rock surfaces on the breakwater and similar species richness to natural rock pools nearby. The artificial pools were also found to provide habitat for several species that were otherwise absent at mid-shore height on the breakwater. The breakwater also supported several sessile species of conservation importance (*S. alveolata*, and *M. edulis*) in higher abundance than nearby natural rock (Evans *et al.*, 2016). Four (150 mm diameter) holes were drilled per rock armour unit (assumed to be 1m<sup>3</sup>), costing ~£200 per m<sup>3</sup>. This compares to between £42 – 107 per m<sup>3</sup> for rock armour (2010 prices). Four pools per m<sup>3</sup> are between 2 to 5 times more expensive than business as usual per retrofitted unit (Evans *et al.*, 2016). The further development of these rockpools are now being investigated as part of the EU Ecostructures Project.

Similarly, core-drilled protective blocks were used to protect the breakwater at Plymouth Sound (Devon). Historically, the concrete block placed to protect the 19<sup>th</sup> century stone breakwater at Plymouth Sound had been cast with a depression where an iron fastening hook was embedded. These depressions have created artificial rock pool habitat. Based on this observation, further pits were core-drilled in protective blocks with differing diameters and distances from each other. The diversity and community structure of colonising epibiota was examined. In total, 33 species were observed in drilled holes and in control areas without drills (functional groups included algae, anemones, hydroids, ascidians, bryozoans, annelids, bivalves, sponges, gastropods and barnacles). Six of the 10 functional groups were found to be unique to the drilled pits (anemones, annelids, ascidians, bivalves, hydroids and sponges) (Firth *et al.*, 2014).

#### 4.2.1.3 Marine scour protection enhancements

Similar to rock armour fronting seawalls along the coast, scour protection is often provided around artificial marine structures, including wind farm foundations, oil platform piles and subsea cables. Similar enhancement measures relating to such features could thus be undertaken to achieve subtidal ecosystem improvements.

Actual case examples of proactive enhancement trials in this field are scarce, however, parallels can be drawn from monitoring of existing structures, as well as feasibility studies.

For example, based on available knowledge on ecological principles and expert judgement of North Sea hard substrate ecology, Bureau Waardenburg (2017) noted that four enhancement options for scour protection are conceivable around wind farm foundations:

- 1. Adding larger structures than conventional scour protection to create large holes and crevices, to provide adequate shelter/holes for large mobile species.
- 2. Adding more small-scale structures than conventional scour protection to create more small-scale holes and crevices but also attachment substrate and settlement substrate.
- 3. Providing or mimicking natural (biogenic) chemical substrate properties to facilitate species. An example is to provide chalk-rich substrate such as concrete with added chalk, or even natural substrate such as shell material.
- 4. Active introduction of specimens of target species to enhance establishment of new populations. This is to facilitate recruitment at locations where reproduction by naturally occurring adults is absent or to scarce.

Furthermore, where new anti-scour marine mattresses are to be fitted, improved mattresses could be utilised which are designed to provide both the scour protection function, as well as enhance the growth of marine flora and fauna and increase species richness to enhance biodiversity. Such a product has for example been developed by EConcrete®; its 'Bio-Enhanced Marine Mattress' product is designed to provide shoreline stabilisation and erosion control as well as anchoring and protecting exposed underwater pipelines (Figure 8) (EConcrete®, 2018).



Source: EConcrete®, 2018

Figure 8. EConcrete® Marine Mattress

#### 4.2.2 Intertidal habitat creation/restoration

Intertidal habitat restoration, and/ or creation, can be considered as a method of enhancement where there is either terrestrial land available at the development site which could be inundated by saline waters, or where there is deteriorating fronting intertidal habitat which could benefit from restoration. The sectors which would most likely undertake such measures are coastal development and ports and shipping, although some projects have in the past also been implemented by water companies.

Managed realignment and regulated tidal exchange are generally the two main techniques employed in intertidal habitat restoration, however there are also several other techniques which can be adopted, including dredging sediment to ‘recharge’ deteriorating habitats, or removing redundant coastal defences and allowing the coast to adjust naturally. Additionally, novel techniques such as creating artificial reefs, or modifying marine structures can be employed (ABPmer, 2017a).

Intertidal habitat creation or restoration can be employed as an onsite or offsite enhancement method. Certainly, on site, these methods would tend to be fairly small scale, unless the related development project is of a substantial scale.

**4.2.2.1 Managed realignment**

The term ‘managed realignment’ is most commonly understood to involve a deliberate breaching, or removal, of existing seawalls, embankments or dikes in order to allow the waters of adjacent coasts, estuaries or rivers to inundate the land behind, to create areas of intertidal habitat.

In most instances, the newly flooded land is low-lying coastal floodplain and therefore a new seawall is needed to clearly define the inundated area and protect the hinterland behind. However, on areas with rising ground either no new line of defences or only a partial counter wall is required. There are essentially 2 different managed realignment methods which can be applied; these are: (1) managed breaching (or breach realignment) and (2) defence removal (or bank realignment).

Figure 9 shows aerial images of the two Welsh realignment schemes. To date, at least 100 managed realignment schemes have been implemented across Northern Europe, 51 of these are in the UK, and two in Wales. Most of these, around 43 in total, have applied the breach realignment technique.



Source: OMReg (<https://www.omreg.net/>); outlines copyright ABPmer

**Figure 9. Ynys Hir managed realignment (Dyfi (Ceredigion)) and Cwm Ivy ‘unmanaged’ realignment (Loughor (West Glamorgan/Swansea))**

The UK schemes were generally implemented on uninhabited agricultural land without significant existing infrastructure or nature conservation designations (though the fronting estuarine habitats have frequently been highly designated). Evidence from implemented schemes suggests that these have generally been successful, and have shown rapid ecological development. However, it is important to ensure that the sites are designed appropriately (e.g. with the correct elevation to deliver certain habitat types and appropriately designed drainage channels and creeks to enhance marsh development and fish usage). Past projects have also shown the value of maximising the degree of morphological complexity in a design to create multiple ecological niches and enhance the level of biodiversity achieved (ABPmer, 2017b).

It is worth noting that managed realignment schemes have also been implemented at relatively small scales. Examples include the 0.5 ha Millennium Terraces installed along some 0.5 km of the Thames estuary near the O2 Arena (see Appendix C), and a recent small-scale scheme along the Camel Estuary in North Cornwall. At the latter, as part of sheet pile upgrading, the replacement defence was set back by six metres and a narrow strip of mudflat created in the process (Naylor *et al.*, 2017a). A relevant example of small scale within-project mitigation managed realignment element is planned along Severn Estuary in the near future. As part of the 'Avonmouth Severnside Enterprise Area (ASEA) Ecology Mitigation and Flood Defence Project', a 1 ha managed realignment is to be undertaken to create saltmarsh (CH2M, 2018).

#### 4.2.2.2 Regulated tidal exchange

Regulated Tidal Exchange (RTE) is considered a subset of managed realignment as it involves the 'landward movement of tidal water'. The distinction is that this is achieved through the controlled exchange of estuarine or coastal waters using pipes, culverts or weirs (ABPmer, 2017a).

The variety of applied RTE approaches is large. They range from simple tidal gates with gaps to allow a finite amount of tidal water through to more complex structures with articulating panels, buoys, and counterweights that can be used to exert control over the timing of tidal exchange (e.g. to ensure that saline waters are extracted from an adjacent tidal river which has a freshwater/marine salt wedge feature). A self-regulating sluice gate is shown in Figure 10 as one example.

To date, a large number of generally small-scale RTE projects (25) have been undertaken in the UK, with the largest being the very recently (November 2018) implemented Cell 4 dynamic lagoon complex on Wallasea Island (132 hectares (ha), Crouch Estuary). The main habitats created have been saline lagoons, saltmarshes and mudflats. The propensity of RTEs leading to saline lagoon creation is related to the reduced tidal amplitude experienced due to the exchange pipes/culverts generally severely restricting exchange, and the pooling of water in lower lying areas.



Low tide



High tide

Copyright: RSPB

Figure 10. Self-regulating tide gate at the Goosemoor RTE (River Clyst, Devon, England)

The cost incurred for habitat restoration through RTE and managed realignment is dependent on the scale and location of the work needing to be undertaken, as well as the extent of engineering work and potential ongoing intervention. As such, managed realignment scheme costs are highly variable, ranging from £790 to £145,000/ha. The average managed realignment unit costs were found to have been approximately £38,000/ ha (ABPmer, 2017a), with costs of compensatory schemes generally being at least twice as expensive.

However, it should be noted that managed realignment projects generally lead to long-term cost savings in terms of flood risk management, particularly where a given embankment is in a poor state of repair, for example at Medmerry, annual costs of re-shaping the shingle bank of £300,000 (in 2009 prices) are now no longer required (see Appendix C for more detail).

#### 4.2.2.3 *Soft sediment recharge*

Soft sediment recharge in intertidal areas is a process by which dredged sediments are placed over or around intertidal mudflats and saltmarshes to either create habitat (most often saltmarshes), or restore or protect intertidal habitats from ongoing erosion (Nottage and Robertson, 2005; Cefas, 2009; Defra and Environment Agency, 2007). This approach is particularly valuable for protecting habitats that are sediment starved or subject to erosion and where the introduction of dredge arisings will allow the habitat to cope with, or respond to, sea level rise.

In the UK, approximately 20 intertidal recharge projects have been undertaken to date; some of which recur on a regular basis. These have been mainly in Essex, Suffolk and on the South Coast. Two of these projects (Allfleet's Marsh and Trimley Marsh) are managed realignment schemes which included the beneficial use of dredged sediment as land forming materials prior to breaching the sea walls (see Figure 11 for an image showing one of the recharge campaigns at Allfleet's Marsh). None of the known schemes have involved intertidal mudflat or saltmarsh creation from subtidal habitats. A case study for the Boiler Marsh scheme in Hampshire, England, is provided in Section 11.2.



Copyright: Defra

Figure 11. Large-scale (550,000m<sup>3</sup>) beneficial use of dredged silt for pre-breach land forming at Allfleet's Marsh on Wallasea Island (Essex, England)

In many estuaries in the UK, fine materials dredged during maintenance and capital dredging campaigns are deposited in a subtidal location within the same estuary; not to create mudflat from subtidal, but to essentially trickle charge sediment back into the estuarine system. Some notable national examples of this 'sustainable relocation' of dredged sediment include the Humber Estuary (Lonsdale, 2012), the Stour and Orwell Estuaries, the Dee Estuary and Poole Harbour. The hypothesis behind this sediment retention approach is that there is a net balance between the amount of material being deposited and eroded in many tidal estuaries. Such a balance may be disturbed when an estuary is dredged, and continuous permanent removal of materials could eventually lead to erosion of intertidal habitats (Cefas, 2009).

The direct placement of material onto the subtidal in order to elevate an area into the intertidal, and thus create mudflat, has never been practiced in the UK. There have, however, been examples of this in the USA and Japan, where recharge has been very widely practiced for decades (PIANC, 2009). Several large-scale port expansion projects have also recently demonstrated that elevations can be built up from subtidal, albeit requiring significant engineering effort (for example, the 2,000ha Maasvlakte 2 expansion at the port of Rotterdam (Port of Rotterdam, 2014)).

It is noted that carrying out beneficial or 'alternative' use projects using fine/silt sediments can be technically challenging and costly. For this reason, the extent to which such materials are used is very limited (ABPmer, 2018). Several initiatives have been, and continue to be, undertaken to address the known barriers to implementation and facilitate the increased actual use of this technique (e.g. the RSPB's ongoing SEABUDS project (Precipitating a SEA Change in the Beneficial Use of Dredged Sediment)<sup>11</sup>, as well as regional initiatives such as the Solent Forum's BUDs project (Beneficial Use of Dredging in the Solent)<sup>12</sup>.

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<sup>11</sup> <https://www.rspb.org.uk/globalassets/downloads/documents/conservation-projects/seabuds-report.pdf>. [last accessed December 2018]

<sup>12</sup> [http://www.solentforum.org/services/Current\\_Projects/buds/](http://www.solentforum.org/services/Current_Projects/buds/) [last accessed December 2018]

Costs of recent projects were reviewed by ABPmer in 2017 and are summarised in Table 3; costs were observed to vary widely, chiefly depending on methods employed, as well as distances and locations.

Table 3. Indicative fees for selected soft sediment recharge work (expressed as £m<sup>-3</sup> of sediment moved)

Project	Sediment Composition and Retention	Distance	Estimated Cost £ m <sup>-3</sup>
Direct intertidal recharge examples			
Maldon, Blackwater	Backhoed and 'dewatered' sediment; no fencing	1.5 to 2.5 km	£12.5 m <sup>-3</sup>
Loder's Cut Island, Deben	Backhoed and 'dewatered' sediment; no fencing	800 m	£20.5 m <sup>-3</sup>
Boiler Marsh Lymington (Wightlink Project)	50% sediment in pumped with water; 10 poldered fences with 3 m high stakes. Hay bales inlaid into fences and placed below them (to stop under cutting)	2 km	£122 m <sup>-3</sup> as average over two years (2012 to 2013)
Lymington Intertidal Restoration (Lymington Harbour Commission Project)	25% sediment in pumped with water; polder fences/faggots, coir mats and a hay bale structure as well as corrugated plastic sheeting where needed	200 m	£32 m <sup>-3</sup> as average over two years (2012 to 2013)
Suffolk Yacht Haven (SYH) Levington, Orwell	10% sediment in pumped with water; various techniques between locations includes: wattle hurdles, faggots (bundles of twigs) or coir logs	300-600 m	£8-9 m <sup>-3</sup>
Other examples (not necessarily direct intertidal recharge)			
Lymington Intertidal Restoration (Lymington Harbour Commission Project)	Sediment bottom dumped in the shallow sublittoral fronting Boiler Marsh	1 to 2 km	£10.02 m <sup>-3</sup> as average over three years (2014 to 2016)
Ems Estuary (Germany) Federal Waterways and Shipping Agency	Sediment pumped with water onto agricultural fields	7 km	6.8 € m <sup>-3</sup> in 2015

Source: ABPmer, 2017b

#### 4.2.2.4 Beach nourishment (sand/shingle recharge)

Beach nourishment (also known as beach recharging and replenishment) involves importing sand or shingle/gravel onto beaches to compensate for losses due to erosion (see, for example, CIRIA, 2010). The imported material is most commonly placed in the intertidal zone, though subtidal and non-tidal placement may also be practiced. Material can be placed using various techniques, depending on factors such as grain size, volumes, source of materials and re-nourishment aims. Hydraulic methods would generally be used for marine based sources, including re-use of navigational dredged materials (CIRIA, 2010).

Whilst typically motivated by flood risk and amenity drivers, beach nourishment can have numerous environmental/ecological benefits, particularly where a given beach is rapidly disappearing due to erosion. Nourishment can thus help to prolong the life of a beach (and its dunes, if present) and related flora and fauna. Potentially significant adverse ecological effects can occur during the construction of such

schemes, and also at the sediment extraction sites. Also, great care is required with regard to the characteristics of the materials, whereby the nourishment material should be as similar as possible to the 'indigenous' sediment (including aspects such as size, grading and shell content) (CIRIA, 2010; Peterson and Bishop, 2005).

Nourishment campaigns are typically undertaken on a regular basis, thus it is reasonable to assume that a beach which has been re-nourished in the past may need to be re-nourished again in the future (CIRIA, 2010).

Beach nourishment is widely practiced across the globe, and costs vary. Linham *et al.* (2010) quote unit costs of beach nourishment in the US of US\$3 to 15/m<sup>3</sup> (at 2009 price levels; *circa* £4-12 in today's money). In the UK, higher costs are typically quoted, for example, a 2005 shingle recharge scheme at Whitstable/Kent apparently incurred volume costs of £30/m<sup>3</sup> (2005 prices quoted by CIRIA, 2010; £44 in today's money). The Environment Agency (2015) reports widely ranging unit costs of £350 to £6,450 per metre. Such costs chiefly vary depending on material type, haulage distance, fuel and plant costs. Volume costs for schemes quoted by the Environment Agency (2015) ranged from £9 to £32/m<sup>3</sup> (2010 prices, so £11 to £40 in today's money; all schemes located in England).

Some examples of recent recharge projects in Wales include the following:

- 'A number of wider coastal protection schemes' from the early 1990s, including at Llanelli, Machynys and Llandudno West Shore. Some 100,000 – 150,000 m<sup>3</sup> were placed at these and other locations, mostly from offshore sources (McCue *et al.*, 2010).
- The Borth Coastal Protection Scheme (Ceredigion), which involved the placement of some 150,000m<sup>3</sup> of shingle, as well as the creation of an offshore 'double' reef and a series of onshore rock groynes. The total costs of this scheme have been quoted as 'over £18 million' (Welsh Government, 2015);
- Colwyn Bay Waterfront (Conwy): 500,000 tonnes of sand placed in 2013/14 (Conwy Borough Council, 2019);
- Neath (Port Talbot) navigational dredging arisings re-use: Since 2000, dredged sands (and sometimes gravels) have frequently been deposited at nearby beaches, including (Pye and Blott, 2014)<sup>13</sup>:
  - 2000: *circa* 10,000 m<sup>3</sup> at Sker Beach (Kenfig Sands);
  - 2003 and 2006: *circa* 65,000 tonnes at Aberavon beach;
  - 2008: 200,000 tonnes at Crymlyn Burrows;
  - 2009: 40,000 tonnes 'placed in the neighbouring dunes';
  - 2010: 50,000 tonnes spread at Aberavon beach;
  - 2012: 110,000 tonnes 'deposited within the [nearby] dunes'.

Beach nourishment is particularly relevant in Wales, as beaches are a key natural, social and economic resource here. They not only provide a vital coastal defence function for local communities, and material for the maintenance of key natural habitats of national and international importance, but 'they also represent one of

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<sup>13</sup> Further campaigns have likely since taken place at this location (pers. comm., NRW).



Wales's premier landscape and recreational assets which underpins coastal tourism' (McCue *et al.*, 2010).

Against this background, a study has been carried out with funding from the Welsh Government to identify ways in which a pattern of dune decline might be reversed through a programme of dune rejuvenation. This research noted that beach nourishment could be valuable at the following Welsh case study sites (Pye and Blott, 2012):

- Kenfig Burrows (Bridgend);
- Merthyr Mawr Warren (Bridgend);
- Laugharne & Pendine Burrows (Carmarthenshire);
- Gronant Dunes and Talacre Warren (Flintshire), and
- Llangennith Burrows (Gower/Swansea).

The latter report also noted a number of smaller scale dune rejuvenation/intervention options which could be classed as 'enhancement', including:

- increased stock grazing,
- scrub clearance,
- stripping of areas of fixed grassland vegetation,
- creation of artificial trough blowouts in frontal dunes,
- excavation of artificial 'blowouts' in inland dune areas,
- localized placement of excavated sand to enhance local wind flow, and
- removal of artificial features which impede the operation of natural processes.

A comparatively new method of sediment recharge is also noteworthy here: the 'Sand Engine' or 'Sand Scaping' method. This is a form of nourishment, whereby large amounts of sand or shingle are applied to a discrete area of the shoreline. This material is then redistributed by wind and waves, stimulating natural development of the coast. This new method of nourishment was first applied (and conceived) in the Netherlands. It aims to serve more functions than flood protection alone, such as increasing the coastal buffer zone, and enlarging the coastal intertidal zone for recreational and ecological benefits.

The Dutch Sand Engine (see Figure 12) was implemented in South Holland in 2011, by depositing 21.5 million m<sup>3</sup> of materials at a cost of €70 million. It has an expected lifetime of 20 years, relieving sand nourishment efforts for this period, it is therefore predicted to be more efficient and effective than traditional recharge methods which are typically undertaken every 3-5 years. However, there are still many uncertainties, for example regarding the speed of the sand dispersal and hence the lifetime the nourishment (Stive *et al.*, 2013).

A small variation of this Sand Engine concept was recently trialled in Poole Bay (2014-2017), the first time the method has been applied in the UK. This scheme made use of 35,000 m<sup>3</sup> of locally-dredged sediment which was placed subtidally near to the shore, allowing the prevailing waves and tidal currents to move material toward and along the beach. 14 months following deposition, monitoring showed that some sediment had moved shoreward to the beach, however it was considered difficult to assess the long-term fate of the stockpile material (Environment Agency, 2018). This

project cost around £275,000 in total, of which 35% (£95,000) was for the actual dredging and placement itself (i.e. £2.7/m<sup>3</sup>) while the remainder of the fee was for the licensing (£20,000) and monitoring (£160,000).

A £22 million 'sand scaping' scheme has also recently been approved by planners in Norfolk (at Bacton, see BBC, 2018a). This would involve the placement of 1.5 million m<sup>3</sup> of sand in front of the Bacton Gas Terminal. This sand will then be allowed to move in an easterly direction with the net littoral drift.



Source: Stive *et al.* 2013

Figure 12. Aerial photograph of the Dutch Sand Engine after completion (September 2011)

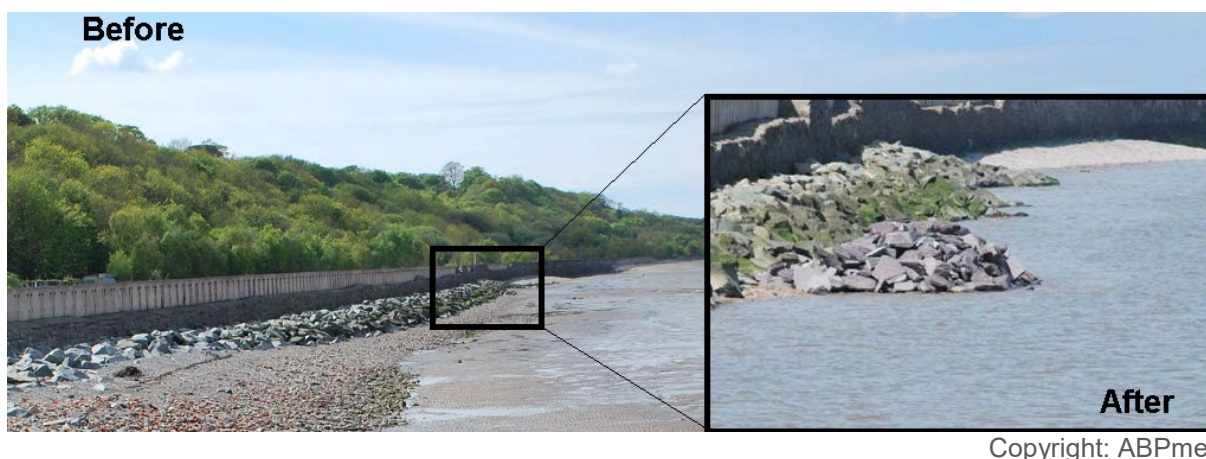
#### 4.2.3 Fish and bird enhancements.

##### 4.2.3.1 Bird enhancement measures

Measure to enhance existing habitat or create suitable habitat for tern species has been used widely both in the UK and abroad. Newly formed islands and rafts have the potential to provide higher quality, and more undisturbed, habitat than nearby natural habitat. This is because they are initially vegetation free, usually lack mammalian predators and their inaccessibility will often limit human disturbance. This could reduce the need for other measures such as fencing and wardening.

Previous studies have found that nest success can be higher on artificial habitats (82 %), than in the natural habitat (58 %) (Pakanen *et al.*, 2014). As such, artificial habitats can be very productive breeding sites for habitat deprived tern populations, but management should focus on improving both natural and artificial habitats.

A pertinent Welsh example can be found in the Dee Estuary, where the Port of Mostyn deposited slate materials to raise a section of upper intertidal zone and create an area that is exposed (and accessible by roosting waterbirds) on most high waters (see Figure 13). This measure was relatively inexpensive because it involved translocating locally available materials a very short distance away within the boundaries of the dock estate.



Copyright: ABPmer

Figure 13. Port of Mostyn (Dee, Flintshire) high tide bird roosting feature

Other such examples of habitat enhancement to support birds include:

- The creation of isolated islands within managed realignment sites (e.g. 12 islands created as part of the Medmerry project (West Sussex, England); some of which were shingle-topped) (ABPmer, 2015);
- The creation of skear/cobble habitats to act as sub-roosts and supplementary feeding grounds for wading birds (e.g. Morecombe Bay case study in Section 11.3);
- The installation of floating saltmarsh islands to provide bird roosting and fish hiding places (see Swansea dock case study in Section 11.4);
- The use of rafts in sheltered harbours and estuaries covered in suitable substratum such as gravel, sand or shingle (Dunlop *et al.*, 1991; RSPB, 2018) (e.g. see Figure 14);
- The creation of a new island habitat feature for terns (Burgess and Hiron, 1992; Fasola and Canova, 1996);
- The addition of suitable nesting substratum to an existing beach, spit, dock or island features not currently used as a nesting site by terns (Pakanen *et al.*, 2014; Flyde Bird Club, 2018; Allcorn, 2003); and
- The addition of suitable nesting substratum to enhance existing colonies (Langstone Harbour Board, 2013, 2014; Allcorn, 2003).



Source: RSPB, 2018

Figure 14. The RSPB's successful Hayling Island (Hampshire, England) tern rafts

Costs of such measures can be relatively low, though this may be due to them often being undertaken by NGOs which are able to utilise volunteer effort. For example, the large Hayling Island (Hampshire) tern raft cost just over £1,000 in material, manufacture and delivery. However, the raft creation, launching and retrieval took a total of around 2 weeks of staff time as well as around 200 volunteer hours. With tern rafts/nesting facilities, it is worth noting that these need to be in locations where terns and shorebirds already attempt nesting in very close proximity. They may also need to be launched/put together and retrieved/deconstructed each year so as to offer new nesting spaces in a given area where the premium nesting sites have already been occupied by other more dominant species. However, the RSPB notes that, if there were no highly species-specific requirements, then creating long-term seabird habitat can be 'a lot easier'. This is provided that there is a food source within an appropriate distance for the species in question and that the species is already being observed in the vicinity. In such a case, creating an expanse of sand/shingle or vegetated shingle on a given structure or beach could be sufficient. Examples include flat roofs, unused jetties, marina pontoons, etc. (pers. comm. RSPB Langstone and Chichester Harbours/ABPmer, January 2019).

Wardening is also a method of site enhancement. The use of wardening schemes and cameras to identify intruders (predators or human) entering zoned off areas can be employed to protect tern nests. The presence of full-time and/or volunteer wardens to protect the area is considered essential for the protection of eggs at most UK colonies. Several sites such as North Denes (Norfolk) and Chesil Beach (Dorset) undertake surveillance around the clock both day and night. Other colonies such as the little Tern colony in Gronant Dunes (North Wales) use trail camera technology to monitor predators at night (RSPB, 2010; ABPmer, 2015).

Limiting access to nesting colonies via the addition of roped off areas, fencing or more sophisticated mesh electric fencing can be implemented to a development as an enhancement measure. The exclusion of disturbance sources and predation from an area is a commonly used technique to help protect nesting birds. For example, nests have been protected on Lindisfarne since 1993 where Oystercatchers were the primary predators and this site has maintained a 100% success rate since implementation (Allcorn, 2003). Such methods can also be used to enhance areas with high levels of tourism or coastal recreation.

Enhancement activities for other bird species have also been undertaken. For example, the creation of nesting sites for Kittiwakes as part of a pier development at Swansea bay. Kittiwakes have been nesting on the old Mumbles Pier for over 20 years, but their nesting habitat was likely to be disturbed as part of a scheme to build a new lifeboat station at the end of the pier, to mitigate the disturbance or loss of habitat new wooden platforms were added to the adjacent pier to create additional nesting habitat. The platforms proved successful with the kittiwakes moving to the new platforms to nest (Figure 15).

However, for nesting structures like this to be properly utilised they have to be deployed in habitat already occupied by kittiwakes, or the target species. They are therefore most effective as onsite enhancements.



Copyright: ABPmer

Figure 15. Pier development at Swansea Bay and site enhancement through placement of Kittiwake nesting platforms at Mumbles Pier

#### 4.2.3.2 Fish enhancement measures

With regard to fish, many of the measures listed above would lead to an improvement in habitat quality for fish; for example, managed realignment schemes have been noted as providing fish nursery and spawning habitats (ABPmer, 2017a). Further fish specific enhancement measures which could conceivably be implemented include the installation of fish passes, and other similar measures which facilitate migratory fish passage. For example, the English Environment Agency has installed several self-regulating tide gates at some drainage outfalls to improve fish passage (as such gates are lighter and can open more fully and frequently than traditional heavy flap gates) (Environment Agency, 2011).

One on-site example is also available from a port developer, implemented as a mitigation measure. In 2015, Associated British Ports (ABP) installed a flapped fish pass on the River Freshney at Grimsby (Lincolnshire) to improve fish passage upstream of the Grimsby Dock system, in close cooperation with the Environment Agency. The fish pass now offers connectivity between the estuary and upstream water systems, enabling the free passage of eel and other fish species.

#### 4.2.4 Other habitat modification

Further habitat modification techniques which do not easily fit into the above categories could include:

- Vegetation enhancements,
- The creation /introduction of reefs;
- Intertidal and subtidal seagrass restoration; and
- Marine habitat restoration.

These measures are discussed below. It is worth noting that many further measures are conceivable, but as these are not well studied, they are not further elaborated upon here. Such measures could for example include the removal of an invasive non-native species from an area, or revised vegetation management on seawalls, etc.

#### 4.2.4.1 Vegetation enhancements

There are various options for enhancing vegetation biodiversity at a given development site, which would very much depend on local conditions. Conceivable measures include planting/seeding of bare patches, grazing of reedbeds and saltmarshes to increase biodiversity and suppress growth, and introducing substrate to facilitate growth.

An example project using vegetative communities to enhance sea defences was undertaken by the Environment Agency in 2012. Instead of using like-for-like concrete materials to repair a seawall at a SSSI site, gabion baskets and clay backfill were used to encourage saltmarsh colonisation. The clay backfill design helps to re-establish saltmarsh habitat in a sheltered estuarine setting. The trial vegetated terraces were only very slightly more expensive than traditional repair costs, around £660/m as opposed to the traditional blockwork repair that typically costs £631/m (Cousins *et al.*, 2017). The overall integrity of the scheme was tested under significant tidal and storm surge conditions in early December 2013 with no loss of structural integrity (Naylor *et al.*, 2017a).

As part of improvement works prior to the Millennium celebrations the Environment Agency took the opportunity to repair sheet piling using enhancement methods. Two areas of intertidal terracing were created on the Greenwich Peninsula, London; one at Blackwall Point and the other at the Eastern River Wall. At the two locations sheet pile wall was cut down to near beach level and capped and either sheet piling or a concrete wall was installed between 7-15 m inland. The space between the old and new sheet piling (or concrete wall) was then used to create stepped and/or sloped saltmarsh habitat. Stepped terraces were created using gabions or wooden piles and in-filled with sediment of similar characteristics to that found locally and planted with saltmarsh species. The whole habitat creation scheme cost £12 million, approximately £17,000 per linear metre, approximately half the anticipated cost of removing, disposing of and replacing the existing sheet piling (Naylor *et al.*, 2017a).

#### 4.2.4.2 Reef restoration/creation

##### **Oyster reefs**

Oyster reefs provide important marine habitats, which improve the water quality and create microhabitats for other marine life, increasing an area's biodiversity. Several oyster restoration projects have been undertaken in the UK to restore populations and enhance reef environments.

With regard to shellfish, it is noteworthy that there have been many oyster restoration projects in the past, mostly motivated by commercial interests. These have however frequently been unsuccessful (e.g. Eagling, 2012). Restoration techniques can be summarised as follows:

- Re-laying of adult oysters;
- Re-laying of spat (very young oysters); and
- Provision of shell cultch (substratum for larvae to settle) directly on the sea bed.

For example, the Solent Oyster Restoration Project led by BLUE is restoring the native oysters to the Solent. So far, over 20,000 native oysters have been restored through a broodstock programme. In addition, the project has placed adult oysters in cages hung under several marina pontoons. The cages help protect adult oysters whilst allowing them to reproduce which helps re-seed wild areas.

Although there are few examples of reef restoration as part of developmental enhancement, one example can be found at Glenmorangie, a whisky company in Scotland, which is aiming to create a native oyster reef to enhance marine biodiversity in the Dornoch Firth area. Initially in 2017, 300 oysters were placed in the area to confirm the species could survive. These initial oysters thrived, which has paved the way for the Dornoch Environmental Enhancement Project (DEEP), whereby shell clutch has been provided, and about 20,000 oysters are being placed on this in a grid formation (see Figure 16). The aim is for the reefs to become self-sufficient and sustain 4 million oysters in a 40 ha area (BBC, 2018b).



Source: BBC, 2018b

Figure 16. Divers placing oysters on shell clutch in the Dornoch Firth (Highlands of Scotland)

As part of the Tidal Lagoon Swansea Bay project (TLSB), the reintroduction of Native Oyster to Swansea Bay was proposed. It was envisaged that oysters would be harvested using trawls from within the footprint of the tidal lagoon. These would then be stored during construction and used to develop a local brood stock for oyster production. Had the lagoon been constructed (it is currently on hold), a hatchery within the lagoon was envisaged; it would then have provided an example of enhancement through co-location of aquaculture and renewable energy activities (TLSB, 2015).

### **Sabellaria reefs**

The Honeycomb Worm *Sabellaria alveolata* is a tube dwelling species of polychaete worm that is found in the intertidal, and occasionally subtidally, in areas with high near bed flow rates and high sandy sediment bedloads. Where the reefs are relatively stable the structural complexity of the biogenic habitat can facilitate functional habitat space for epiphytes, infauna, and epifauna, as well as for mobile species such as crustaceans.

As part of the TLSB project, the translocation of existing *S. alveolata* reef within the Swansea Bay system was investigated. The western landfall of the proposed TLSB development's seawall was directly overlapping with *S. alveolata* reef in the intertidal area at Port beach, thus, translocation of *S. alveolata* reef was proposed to reduce the impact of removal and substratum loss.

The pilot study translocation was undertaken on 6 June 2014. The *Sabellaria* reef in Swansea Bay is formed of sheets colonising boulders and cobbles. This structure allowed 'blocks' of reef (approximately 30 cm<sup>2</sup>) to be lifted and translocated to the new 'receptor' site.

Results indicated that translocation of *S. alveolata* reef blocks to the receptor site was successful, with all translocated specimens surviving. Therefore, habitat enhancement measures for *S. alveolata* reef should focus on translocation of existing reef structures from within an impact zone and relocating to a new viable receptor site. However, it is important to consider that these insights were based on a five-week monitoring period only (Reach *et al.*, 2015).

### **Artificial reefs**

The installation of artificial reefs is well-established elsewhere in the world; however, there are few UK examples. Generally, it has been estimated that around 50 % of artificial reefs are successful (Baine, 2001), with the key to success lying in building a reef in harmony with the surrounding environment and therefore undertaking a careful, site specific, design process. There is furthermore overlap between artificial reef and the enhancement measures discussed in Section 4.2.1.

One UK example where a reef has been installed is the Poole Bay artificial reef, which was created in 1989 off the South coast of England. Reef structures were constructed from concrete blocks and cement stabilised pulverised fuel ash (PFA) from power stations. The reef was designed to assess the environmental acceptability of this novel material. The reef was then subject to a monitoring programme to study a number of factors related to the environmental acceptability of the materials but also to observe the changes in fauna close to the reef and the fisheries potential of the structures. The monitoring programme showed that the reef blocks were rapidly colonized by a wide variety of epibiota, fish and crustaceans. Experiments such as the Poole Bay reef show that artificial reefs do actively encourage marine life (Jee, 2017).

This method is not, however, considered by NRW to be a form of enhancement when applied in areas of naturally soft sediment. This method would only be advocated as part of a licensed development where structures such as breakwaters might be needed, and therefore as a method of enhancing the licensed structure.



#### 4.2.4.3 Intertidal and subtidal seagrass restoration;

There are four species of seagrass found in Welsh waters, including *Zostera marina*, *Zostera noltii* and two *Ruppia* spp. (included in the Section 7 definition). *Zostera marina* is the largest of the British seagrasses and typically occurs in the shallow sublittoral down to about 4 m depth, in fully marine conditions and on relatively coarse sediments. Dwarf eelgrass, *Z. noltii* occurs higher on the shore than the other species, typically on mixtures of sand and mud.

Seagrass restoration has been conducted for over 50 years, and the means of doing this can principally be split into 2 major techniques:

- Replanting; and
- Reseeding.

Both techniques have their relative merits and have exhibited varying levels of success. A broad overview of the literature illustrates that, although seagrass restoration has been trialled numerous times, the success rate of restoration projects is still often very low. The use of re-seeding generally relates to the collection and targeted redistribution (and sometimes processing) of wild seed. Adult shoot replanting normally involves harvesting plants from an existing meadow and transplanting them to the restoration site. This is because there is generally no readily available source of nursery grown plants.

In most cases, some means of anchoring the shoots to the bottom is necessary until the roots can take hold (root into the bottom). Replanting uses either labour-intensive diving techniques or various mechanistic approaches to planting various sizes and ages of seagrass plants into new localities. In the US, reseeded and replanting techniques have sometimes been used together. Using seeds possibly in conjunction with adult plants may in some instances prove more effective (van Katwijk *et al.*, 2016).

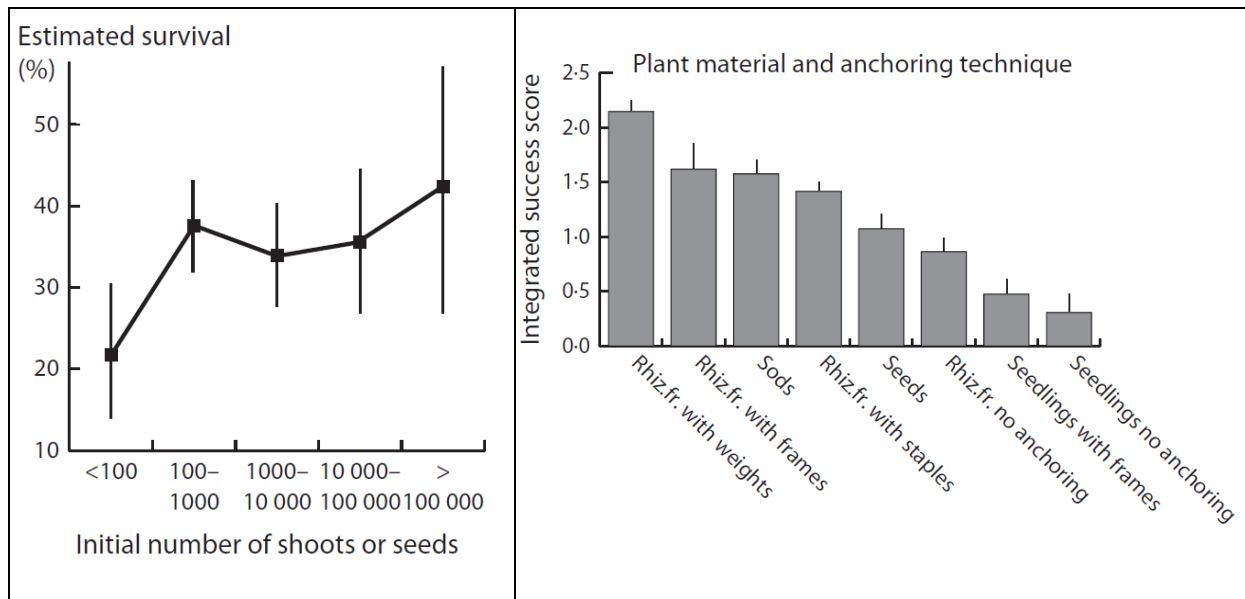
Seagrass restoration has the capacity to be both very expensive and have a high risk of project failure. With regard to costs, Bayraktarov (2016) quote median to average per-hectare costs of between £85,000 and £310,000 for seagrass restoration (2018 prices)<sup>14</sup>.

Historically, failures have often been due to suboptimal consideration of the habitat requirements for seagrass and the continued presence of the stressor that caused the original seagrass loss (e.g. eutrophication). A recent global review study also highlights the need for restoration to occur at sufficient scales in order to facilitate positive feedbacks and to spread the chances of success (see Figure 17) (van Katwijk *et al.*, 2016). With regard to techniques, seeds, adult plants and intact units of native sediment with roots (sods) were not found to be significantly different, although seedlings showed lesser planting results. A short distance to the donor site was also

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<sup>14</sup> based on a global analysis of 64 projects, UK £ prices calculated based on 2010 exchange rate and taking account of inflation to 2018.

related to success. Whereas transplantations (replanting) frequently fail (60%) or have limited success, a substantial number of transplantations showed substantial expansion rates (van Katwijk *et al.*, 2016).



Source: Katwijk *et al.*, 2016

Figure 17. Influence of restoration scale and method on seagrass survival and growth

Bos *et al.* (2005) describe attempts by the Dutch authorities to reintroduce seagrass to create a stable population in the Dutch Waddenzee. The rationale behind the programme was to create a source stock for further recovery and expansion along the coast. Site selection was considered to be highly important, with locations chosen using the following criteria (Reach *et al.*, 2015):

- Areas where *Z. marina* was known to have been present/grown naturally in the past;
- The area should have natural protection against prevailing winds;
- The area should have some freshwater input; and
- No fishing activities, or bait digging, should be allowed in, or within proximity of, the area.

In the UK, the only known seagrass restoration trials to date (by Swansea University at Porth Dinlleian, North Wales and TLSB at Swansea) have been considered a failure (pers. comm. Richard Unsworth).

#### 4.2.4.4 Marine habitat creation/restoration

This section was mainly included in order to discuss enhancement measures related to the aggregates sector. For this sector, it is worth noting that a myriad of mitigation measures are routinely observed in order to limit impacts from their activities (summarised in BMAPA and The Crown Estate, 2017). There are few examples of actual enhancement measures in the aggregate sector. Previously, there has been discussion of sediment seeding at aggregate sites following cessation of aggregate extraction, which could be an example of enhancement (e.g. Tillin *et al.*, 2011).

Marine habitat creation /restoration through the placement of aggregates is also conceivable to re-create fish habitat, e.g. gravelly habitat for herring spawning, or sandy habitat for sandeel colonisation. However, no examples of such restoration projects have been found.

### 4.3 Offsite Enhancements

Offsite enhancements are those that take place away from a development site. These can be designed to work with natural processes and to restore natural features. In addition, offsite enhancements do not necessarily have to replace or enhance the habitat being impacted by development but instead could be used to enhance alternative habitat or restore a locally scarce resource. Some examples are discussed in the sections below.

#### 4.3.1 Stock enhancement

Aquaculture-based fisheries enhancement incorporates a set of management approaches involving the release of cultured organisms to enhance, conserve, or restore fisheries. Aquaculture-based enhancements can, at least in principle, generate a range of benefits. In biological terms, enhancement can (1) increase yield through manipulation of population and/or food web structure, thus raising fisheries production at low external inputs and degree of habitat modification; (2) aid the conservation and rebuilding of depleted or threatened populations; and (3) provide partial mitigation for ecosystem effects of fishing (Lorenzen, 2008).

For example, utilising hatchery-reared juvenile animals for stocking natural habitats for 'ranching' or stock enhancement has been successful in a few locations around the UK coast (MMO, 2013). However, the hatchery set up capital costs are very high at between £450,000 and £750,000, according to Rodmell and Todd (2008) which would amount to £590,000 to £980,000 in 2018 money.

A 2013 MMO report estimated the current unit running costs of a lobster hatchery would be around £6.62 per kg of lobsters. If that were considered to be a licence fee payable per kg by the benefiting fishermen they would, under current assumptions, be beneficiaries by the difference between this amount and the current market price of lobsters (£20 minus £6.62, or £17.38 per kg (2013 values; £19.6 in 2018 prices)).

#### 4.3.2 Habitat creation, modification or management

The concept of offsite habitat modification and onsite modification are relatively similar to those discussed in Section 4.2, but generally differ in scale and financing.

Offsite habitat modification may involve the purchase or use of an alternative site, away from the development, which is then modified to enhance the habitat. Modification methods can involve, among others, planting of saltmarsh or seagrass habitat, managed realignment, sediment recharge or management of a site e.g. grazing of saltmarsh to increase saltmarsh diversity. Financing is conceivable through mechanisms such as levies paid by developers. Such a levy is, for example, now collected from new housing developments by the authorities along the Solent

marine Natura 2000 sites, in order to finance measures to reduce bird disturbance. The levy equates to around £564 per dwelling (Bird Aware, 2017).

This could also include paying for fish enhancement measures elsewhere in the system. For example, as part of the Green Port Hull development, ABP supported a project to improve the Humber River basin for migratory fish species. ABP awarded the Rivers Trust £180,000 to implement a series of projects that reconnect the upstream rivers within the Humber catchment, to improve the changes of fish successfully spawning and migrating. The results have been described as 'remarkable', with salmon recorded at upstream spawning grounds for the first time in 100 years. Individual projects included the removal of a weir at Breary Banks, installing fish passes along the River Don and installing a channel bypass at the River Laver. ABP's grant also helped the Rivers Trust secure £2 million of additional funding, which in total has led to the opening up of 70 km of habitat for migratory fish (YouTube, 2018).

### 4.3.3 Co-location

Co-location is seen as a means by which the use of marine space can be maximised, and constitutes an example of integrated marine planning around the coastline. The Shellfish Association of Great Britain (SAGB) have recently funded a feasibility study entitled, 'Aquaculture in Welsh Offshore Windfarms; A feasibility study into potential shellfish cultivation in offshore wind farm sites.' This study is investigating the possibility of siting aquaculture projects on offshore wind farm sites. In the short term, this project is centred round research into blue mussels, but aims to investigate the possibility of diversification into other species once experience has been gained.

This project is consistent with the type of activities outlined in the European Commission's Blue Growth Initiative and the findings will provide potential wider benefits not only for the UK aquaculture sector but for other Member States.

## 4.4 Summary Matrix and Cost Table

The matrix in Table 4 below summarises which of those measures outlined in Sections 4.2 and 4.3 above have been, or could be, applied in the key sectors for which marine licenses tend to be sought in Wales. Offsite enhancement in particular could be interpreted in a very wide fashion, if enhancement were to be interpreted in the widest 'environmental net gain' sense (hence all measures which have not been employed being marked as 'potential to incorporate').

Table 5 summarises the available cost information for the various techniques, based on costs highlighted in Sections 4.2 and 4.3.

Table 4. Matrix of potential enhancement options for each sector (✓ - already employed, o – potential to incorporate, n/a – not applicable)

	Coastal Development	Aggregates	Aquaculture	Defence	Dredging and Disposal	Renewable energy	Oil and gas	Fisheries	Ports and shipping	Subsea cabling	Surface water and wastewater treatment	Tourism and recreation
<b>Onsite enhancements</b>												
Vertical structure enhancements	✓	n/a	o	✓	n/a	✓	✓	n/a	✓	n/a	o	✓
Rock armouring	✓	n/a	o	✓	n/a	✓	n/a	n/a	✓	n/a	o	o
Scour protection		n/a	o	n/a	n/a	✓	✓	n/a	✓	✓	o	o
Managed realignment	✓	n/a	n/a	✓	n/a	n/a	n/a	n/a	✓	n/a	o	n/a
Regulated tidal exchange	✓	n/a	n/a	✓	n/a	n/a	n/a	n/a	✓	n/a	o	n/a
Sediment recharge / nourishment	✓	✓	n/a	✓	✓	o	o	n/a	✓	o	o	o
Bird enhancement measures	✓	n/a	o	✓	n/a	o	o	n/a	o	n/a	o	✓
Vegetation enhancements	✓	o	n/a	✓	n/a	✓	✓	o	o	o	✓	o
Reef restoration	✓	o	o	✓	n/a	o	o	o	o	o	n/a	o
Artificial reef creations	✓	o	o	✓	n/a	✓	✓	o	✓	o	n/a	o
<b>Offsite enhancements</b>												
Stock enhancement	o	o	✓	o	o	o	o	o	o	o	o	o
Offsite enhancements: Habitat management	✓	o	o	o	o	o	o	o	o	o	o	o
Offsite enhancements: Habitat creation	✓	o	o	o	o	o	o	o	o	o	o	o
Co-location	o	o	o	o	o	o	o	o	o	o	o	o

Table 5. Cost summary table

Enhancement Type	Cost summary
Vertical structure enhancements	Small pool structures: 'Vertipools': generally £175-£600/unit (excl. installation); Confidential 'vertipool' scheme: £2,500 incl. installation and monitoring. Australian 'flowerpots': £170/unit (incl. installation).
	Tiles: EConcrete® seawall tiles: £350/m <sup>2</sup> ; Hartlepool textured panels: £8-30/m <sup>2</sup> (additional cost).
Rock armouring	Rock armour units: Bioblock (prototype): <i>circa</i> £2,000 (incl. transport & installation); EConcrete® 'armouring units': £852/unit (excl. tax & installation); EConcrete® tide pool units: £990/unit (excl. tax & installation).
	Drilling holes in existing rock armour: ~£200/m <sup>3</sup> (Tywyn/Cardigan Bay drilling costs).
Scour protection (incl. reefs)	Material cost from 2017 Bureau Waardenburg report (see Figure 24): Reef balls: £900/unit; Xblock: £700/unit; live oyster cages: £3,500 for 2m <sup>3</sup> .
Managed realignment	UK whole-scheme costs: £790 to £145,000/ha (average <i>circa</i> £38,000/ha).
Regulated tidal exchange	
Sediment recharge / nourishment	UK soft sediment schemes: £8 to £122/m <sup>3</sup> (typical costs between £8 and £32/m <sup>3</sup> ) (including deposition).
	UK beach recharge schemes: £11 to £40/m <sup>3</sup> (including deposition); Poole sand engine: 7.8/m <sup>3</sup> (whole scheme); Bacton sand scaping: £14.7/m <sup>3</sup> (anticipated, approximate).
Bird enhancement measures	Bird rafts: Hayling Island tern rafts: £1,000/raft (materials and delivery only; staff/volunteer time excluded).
Vegetation enhancements	Seawall repair: Severn site: with gabions and clay rather than concrete at: £29/m more expensive than concrete.
	Sheetpile repair: Greenwich: vegetation terrace creation (including setback): £17,000/metre.
Seagrass restoration	£85,000 to £310,000/ha (median to average costs; based on global analysis of 64 projects).
Stock enhancement	Lobsters: £19.6/kg of lobsters.

## 5 Towards a Set of Principles for Enhancement

### 5.1 Introduction

There are important choices to be made about the nature and type of enhancement that might be encouraged through WNMP ENV\_01 and the marine licensing system. These choices should be shaped by working to a set of clear principles.

Various principles have already been established in different contexts, including in relation to the ecosystem approach and for biodiversity offsetting/net gain. A range of wider environmental and governance principles can also be considered relevant. These broad principles are summarised in Sections 5.2 to 5.4 below. Table 6 then discusses the relevance of these principles to the consideration of environmental enhancement in the context of WNMP ENV\_01.

### 5.2 Ecosystem Approach Principles

There are various definitions of an ecosystem approach. A practical interpretation of the ecosystem approach is set out in regulation 5 of the Marine Strategy Regulations 2010 which transpose the MSFD. An ecosystem-based approach to the management of human activities means *'an approach which ensures that the collective pressure of human activities is kept within the levels compatible with the achievement of good environmental status; that does not compromise the capacity of marine ecosystems to respond to human-induced changes; and that enables the sustainable use of marine goods and services'*.

A practical set of principles has also been proposed for implementing the ecosystem approach, known as the Malawi Principles<sup>15</sup>:

- (1) Management objectives are a matter of societal choice.
- (2) Management should be decentralized to the lowest appropriate level.
- (3) Ecosystem managers should consider the effects of their activities on adjacent and other ecosystems.
- (4) Recognizing potential gains from management there is a need to understand the ecosystem in an economic context, considering e.g. mitigating market distortions, aligning incentives to promote sustainable use, and internalizing costs and benefits.
- (5) A key feature of the ecosystem approach includes conservation of ecosystem structure and functioning.
- (6) Ecosystems must be managed within the limits to their functioning.
- (7) The ecosystem approach should be undertaken at the appropriate scale.
- (8) Recognizing the varying temporal scales and lag effects which characterize ecosystem processes, objectives for ecosystem management should be set for the long term.
- (9) Management must recognize that change is inevitable.
- (10) The ecosystem approach should seek the appropriate balance between conservation and use of biodiversity.

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<sup>15</sup> <http://www.fao.org/docrep/006/y4773e/y4773e0e.htm>

- (11) The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
- (12) The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

### 5.3 Biodiversity Offsetting Principles

Numerous documents outlining principles of biodiversity offsetting, Biodiversity Net Gain and more recently Environmental Net Gain have been published. Most of these build on principles originally developed by the Business and Biodiversity Offsets Programme (BBOP) in 2012 on 'No Net Loss and Beyond'. The recent CIRIA/CIEEM/IEMA (2016) 'good practice principles' related to Biodiversity Net Gain for example list the following principles:

- Apply the mitigation hierarchy – projects should seek to avoid or minimise potential impacts before offsetting residual impacts;
- Avoid losing biodiversity that cannot be offset by gains elsewhere;
- Be inclusive and equitable;
- Address risks;
- Make a measurable Net Gain contribution;
- Achieve the best outcomes for biodiversity;
- Be additional;
- Create a Net Gain legacy;
- Optimise sustainability;
- Be transparent.

### 5.4 Welsh Sustainable Management of Natural Resources Principles

The principles highlighted in the Environment (Wales) Act 2016 in relation to sustainable management of natural resources (SMNR) are also worth highlighting. These are as follows:

- Adaptive management - Managed adaptively by planning, monitoring, reviewing and where appropriate changing action;
- Scale - Consider the appropriate spatial scale for action;
- Collaboration and engagement - Promote and engage in collaboration and cooperation;
- Public participation - Make appropriate arrangements for public participation in decision making;
- Multiple benefits - Take account of the benefits and intrinsic value of natural resources and ecosystems;
- Long term - Take account of the short, medium and long-term consequences and action;
- Preventative action - Take action to prevent significant damage to ecosystems; and
- Building resilience - Take account of the resilience of ecosystems, in particular the following aspects:



- diversity between and within ecosystems;
- the connections between and within ecosystems;
- the scale of ecosystems;
- the condition of ecosystems (including their structure and functioning);  
and
- the adaptability of ecosystems.

## 5.5 Wider Environmental and Governance Principles

In addition to the principles discussed above, there is a range of environmental and governance principles that could be considered relevant to environmental enhancement, including:

- Working with natural processes/ nature-based solutions – the extent to which environmental enhancement should be set in the wider context of local marine ecosystem structure and function;
- Sound science – managing risk of failure, taking account of the precautionary principle and the adaptive management principle;
- Public participation – in line with the requirements of environmental decision-making processes, there should be opportunity for the public to participate in the consideration of environmental enhancement measures;
- Polluter pays principle – those responsible for causing damage should be responsible for bearing the costs of offsetting such damage;
- Proportionality (better regulation) – the costs of adopting environmental enhancement measures should be proportionate to the environmental damage and interventions should also be cost-effective;
- Consistency (better regulation) – any process for determining environmental enhancement requirements should be capable of consistent application; and
- Transparency (better regulation) – decision-making processes in relation to environmental enhancement should be clear and transparent.

## 5.6 Relevance of Principles to Environmental Enhancement

Table 6 outlines the relevance and possible application of key principles to the consideration of environmental enhancement in the context of WNMP ENV\_01, and highlights those which are SMNR principles under the Environment (Wales) Act.

Some of the principles, such as application of the mitigation hierarchy and avoidance of damage to irreplaceable features can largely be taken as a given. Further consideration of the following principles is considered to be particularly important:

- Societal choice – greater clarity is required concerning the ambition for environmental enhancement and whether it is intended to provide overall Biodiversity or Environmental Net Gain or whether the level of ambition is merely to achieve some level of positive gain relative to a do-nothing scenario;
- Working with natural processes/ nature-based solutions – adopting such a principle will have significant implications for the type of enhancements that are pursued. For example, on-site measures that increase the heterogeneity

of hard structures in areas of predominantly soft substrate may not be making a significant contribution to local ecosystems; and

- Application of risk-based approach – there is important detail surrounding a risk-based approach that needs to be worked out, particularly if developers are expected to commit to delivering benefits effectively in perpetuity. This will need to explicitly include application of adaptive management to ensure that risks are managed in the long-term.

The ‘working with natural processes’/‘nature-based solutions’ principle in particular could yield many more practical implementation principles, such as:

- Should require minimal future maintenance;
- Must not overly impact natural processes;
- Must align with conservation objectives of designated sites;
- Must not interfere and inhibit the technical function of the structure or impact on structural integrity;
- Bird nesting – undertake where there is existing colony, and there are signs that these could benefit from additional facilities;
- Rockpools - careful consideration of tidal height; and
- Biogenic reefs – undertake where there are existing sites nearby which could provide a larvae source for settlement; etc.

Table 6. Relevance of Key Principles to Environmental Enhancement

Principle	SMNR Principle	Relevance to Environmental Enhancement Policy / Possible Application
Adaptive management	Yes	Enhancements to be managed adaptively by planning, monitoring, reviewing and, where appropriate, changing action. This takes account of the fact that ecosystems change, including species composition and population abundance.
Working with natural processes/sustainability/nature-based solutions	Not <i>per se</i>	Enhancements that work with natural processes / are nature-based are likely to make a stronger contribution to local ecosystems and be more sustainable. There are important choices to be made relating to the extent to which enhancements should work with natural processes.
Scale	Yes	Consider the appropriate spatial scale for action. Environmental enhancements should be at a meaningful ecological scale. Supports approach for nature-based solutions.
Collaboration and engagement	Yes	Promote and engage in collaboration and cooperation. Ideally involve all relevant sectors of society and scientific disciplines.
Public participation (decision-making/ inclusivity/ transparency)	Yes	Make appropriate arrangements for public participation in decision making. Recognise that environmental enhancement should be considered within the context of environmental decision-making processes, which require an appropriate level of public participation.
Long term	Yes	Take account of the short, medium and long-term consequences and action. Environmental enhancements should take a long-term view and account for long-term natural change. Provide a long-term commitment to maintaining enhancement.
Building resilience	Yes	The extent to which environmental enhancement should contribute to the structure and function of local marine ecosystems. There are important choices to be made relating to the extent to which enhancements should work with natural processes and enhance resilience of ecosystem structure
Additionality	No	Enhancements should be clearly additional to existing legal obligations. Need to ensure decision-making processes provide clarity on additionality of enhancement measures.
Proportionality	No	Costs of enhancement measures should be proportionate, affordable and cost-effective. May need to embed proportionality in decision-making process (require inclusion of affordability and cost effectiveness assessments).
Societal choice	No	It is a matter of societal choice the extent to which environmental enhancement should be sought. WNMP ENV_01 promotes environmental enhancement but does not specify the extent of enhancement that should be sought. Further consideration could be given to pursuing an objective of Biodiversity Net Gain or Environmental Net Gain.
Avoidance	No	Projects that pursue enhancements which cause damage to irreplaceable features should not be licensed. Environmental enhancement should not be used to circumvent other requirements.
Evidence	No	Environmental enhancement strategies should take account of all relevant evidence and gather evidence in respect of uncertainties and consider delivery risks. Ensure decisions on environmental enhancement are based on sound science, apply adaptive management and take account of precautionary principle.
Application of the mitigation hierarchy	No	The requirement for and extent of environmental enhancement should be considered once impacts have been avoided or minimised as far as practicable, i.e. only after the mitigation hierarchy has been applied.
Consistency	No	Decisions on enhancements should be taken in a consistent manner. A clear set of principles and process will support consistent decision-making.

## 6 Conclusions and Recommendations

The context review has highlighted that there is a wide variety of legislation and policy documents which refer to environmental measures related to the enhancement concept, be it in its wider or more restricted sense. The context review has further demonstrated that, while there is a lot of aspiration to deliver ecological enhancement in the marine environment, there is limited statutory underpinning of, and guidance related to, this aspiration at present.

Whilst impacts to most nationally and internationally designated sites require mitigation and compensation, there are limited statutory mechanisms that facilitate the adoption of enhancement activities for licensable activities in the marine environment. Further consideration could be given to the statutory underpinning of an environmental enhancement policy particularly in the context of Biodiversity or Environmental Net Gain.

A wide range of examples of environmental enhancement measures has been identified through the literature review. This includes both onsite and offsite measures.

Onsite enhancement initiatives typically involve introducing objects or modifying artificial coastal structures to increase their complexity and/or the roughness of their surfaces. This has become known as 'greening the grey', and is based on the ecological premise that biodiversity is inherently greater where an environment includes multiple microhabitats, niches and refuges against predators and environmental stresses. Aside from modifying structures, a raft of other measures is also conceivable for onsite enhancement, including habitat creation and improving conditions for faunal features.

The findings from the review of current onsite enhancement projects have demonstrated that introducing structural complexity into design can be valuable for enhancing local biodiversity. The ecological and engineering success of armour and seawall enhancements has been very high globally, with enhancements improving local biodiversity within 6 to 12 months of deployment relative to business-as-usual approaches.

Offsite enhancements tend to be more wide ranging and flexible, including direct manipulation/ creation of natural habitats at different scales and levels of complexity. There is increasing experience of interventions such as managed realignment, regulated tidal exchange and sediment recharge to create and restore intertidal habitats as well as a variety of wider measures to support species such as birds and fish.

Onsite environmental enhancement tends to be undertaken at very local scales (often within project design envelopes) and can take the form of 'environmental gardening'. While this can and does work in the terrestrial environment (including saline habitats such as saltmarsh), this scale of intervention can be less relevant in the wider marine environment. This may particularly be the case where marine infrastructure has an operational function (e.g. quay walls, offshore foundations etc.), as such 'gardening' may be further limited by operational requirements. Furthermore,

while onsite measures may increase local biodiversity, the measures may not be in line with natural processes, for example, creating hard substrate in areas that are predominantly sedimentary or creating features at a scale that is not ecologically meaningful. Such interventions may not contribute to the resilience of marine ecosystems nor address key local/regional pressures and impacts affecting the marine environment.

The concept of enhancement in the marine environment therefore requires careful consideration and may be better set in the wider context of Environmental Net Gain and more strategic (regional scale) initiatives to maintain and restore marine biodiversity in line with natural processes.

In developing principles for proportionate implementation of ENV\_01, it is therefore important to consider how far to pursue 'within project' enhancements or to encourage broader enhancement activity within a wider context of environmental net gain. For example, the Area Statements being developed in Wales could be used to drive more strategic enhancement of the marine environment.

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## 8 Abbreviations/Acronyms

ABP	Associated British Ports
ALSF	Aggregates Levy Sustainability Fund
ASEA	Avonmouth Severnside Enterprise Area
BAP	Biodiversity Action Plan
BBC	British Broadcasting Corporation
BBOP	Business and Biodiversity Offsets Programme
BESE	Biodegradable Elements for Starting Ecosystems
BLUE	Blue Marine Foundation
BMAPA	British Marine Aggregate Producers Association
BNG	Biodiversity Net Gain
CBD	Convention on Biological Diversity
CCW	Countryside Council for Wales
CIEEM	Chartered Institute of Ecology and Environmental Management
CIRIA	Construction Industry Research and Information Association
CNC	Cyfoeth Naturiol Cymru
CROW	Countryside and Rights of Way
DCO	Development Consent Order
DEEP	Dornoch Environmental Enhancement Project
dWNMP	draft Welsh National Marine Plan
EC	European Commission
EEC	European Economic Community
EIA	Environmental Impact Assessment
ELD	Environmental Liability Directive
EMS	European Marine Site
ENG	Environmental Net Gain
ES	Environmental Statement
EU	European Union
GBS	Gravity-based structure
GPS	Global Positioning System
HM	Her Majesty's
HRA	Habitats Regulations Assessment
IEMA	Institute of Environmental Management and Assessment
IMO	International Maritime Organisation
IPENS	Improvement Programme for England's Natura 2000 sites
IROPI	Imperative Reasons of Overriding Public Interest
LDP	Local Development Plan
LPA	Local Planning Authority
MALSF	Marine Aggregate Levy Sustainability Fund
MCZ	Marine Conservation Zone
MMO	Marine Management Organisation
MPA	Marine Protected Area
MPS	Marine Policy Statement
MSFD	Marine Strategy Framework Directive
NCC	Natural Capital Committee
NDF	National Development Framework
NERC	Natural Environment Research Council
NRW	Natural Resources Wales
NSIP	Nationally Significant Infrastructure Project

OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PEI	Preliminary Environmental Information
PFA	Pulverised Fuel Ash
PIANC	Waterborne transport, Navigation, Ports, Waterways
PIP	Prioritised Improvement Plan
PPW	Planning Policy Wales
PSB	Public Services Boards
RBD	River Basin District
RHCP	Regional Habitat Creation Programme
RSPB	Royal Society for the Protection of Birds
RTE	Regulated Tidal Exchange
SAC	Special Areas of Conservation
SAGB	Shellfish Association of Great Britain
SDP	Strategic Development Plan
SEABUDS	Precipitating a SEA Change in the Beneficial Use of Dredged Sediment
SIP	Site Improvement Plan
SMNR	Sustainable Management of Natural Resource
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
SYH	Suffolk Yacht Haven
TAN	Technical Advice Note
TAP	Thematic Action Plan
TLSB	Tidal Lagoon Swansea Bay
UK	United Kingdom
UN	United Nations
US	United States
USA	United States of America
WACA	Wildlife and Countryside Act 1981
WFD	Water Framework Directive
WNMP	Welsh National Marine Plan

## 9 Appendix A – Further Detail on Relevant Legislation, Policies and Guidance

The Sections in this Appendix provide further detail to those pieces of legislation, policy and guidance which were summarised in Section 3.2 of this report.

### 9.1 Wild Birds and Habitats Directives

The Habitats Directive is European legislation that aims to protect all species and habitats that are important within Europe and applies to all countries that are part of the European Union. Similarly, the Birds Directive provides a framework for the conservation and management of, and human interactions with, wild birds in Europe. In the UK the Habitats Directives and elements of the Birds Directive have been transposed into UK legislation as the Conservation of Habitats and Species Regulations 2017 (Habitats Regulations). The Regulations provide for the designation and protection of 'European sites', the protection of 'European protected species', and the adaptation of planning and other controls for the protection of European Sites.

Developers with projects that could affect protected sites have to take the Habitat Regulations into account. In this context there is a requirement to determine the impact of the proposed development on the species and habitats protected under the SPA, SAC and Ramsar site designations (and those proposed for designation). This is undertaken through a process known as a Habitats Regulations Assessment (HRA), where developers are required to provide the information needed for the body they are obtaining consent from (the competent authority), to complete a specific type of assessment.

A HRA is typically seen as a four-step process as outlined below.

- Stage 1 – Screening: This is the first phase and is an initial review to establish whether the development will impact on a Natura 2000 site and therefore whether a HRA is required. It should consider not only the proposal alone but in combination with other plans or projects in the area.
- Stage 2 – Appropriate Assessment: Following the screening assessment if the development has the potential to adversely impact a Natura 2000 site then an Appropriate Assessment will need to be completed. The competent authority will conduct this, but details have to be supplied by the applicant.
- Stage 3 – Assessment of Alternatives: If there is any doubt about adverse impacts on site integrity this stage assesses potential measures to avoid impacts or design appropriate mitigation measures, including monitoring, that will alleviate any adverse effects.
- Stage 4 – Assessment of Imperative Reasons of Over-Riding Public Interest (IROPI): Under certain circumstances it is possible to proceed with a plan or project despite a negative assessment of the implications for the site. To do this, the three must be met:
  - There are no alternative solutions;
  - Any necessary compensatory measures are secured to ensure the overall coherence of the network of SPAs, SACs and Ramsar sites; and
  - There are Imperative Reasons of Over-riding Public Interest.

In these circumstances, before such a project can proceed, compensatory measures must be secured to ensure that the overall coherence of the network of Natura 2000 sites is maintained.

## 9.2 Environmental Impact Assessment Directive

The Environmental Impact Assessment (EIA) Directive (2011/92/EU EIA), as amended by the EIA Directive (2014/52/EU), sets out the procedure that must be followed before approval is granted for a range of plans and projects, defined in Annexes I and II of the Directive.

Annex I projects are considered to have significant effects on the environment and EIA is mandatory. The potential for significant effects on the environment as a result of Annex II projects and thus whether an EIA is required, however, is at the discretion of the Competent Authority, having regard to criteria set out in Annex III of the Directive. The EIA Directive is transposed into UK law through a series of regulations. The relevant regulations that apply to a particular project is primarily dependent on the location and type of development.

The EIA process requires a number of steps to be undertaken to assess the potentially significant effects associated with a particular project (and the effects that might occur cumulatively with other plans and projects). These steps include screening, scoping and the preparation of an environmental statement (ES). In England and Wales, for nationally significant infrastructure projects (NSIPs) granted permission under the Planning Act 2008, there is an additional step: the preparation of preliminary environmental information (PEI) prior to the submission of the formal ES.

With regard to marine licensing, the Marine Works (EIA) Regulations 2007 (as amended) implement these directives in the UK.

## 9.3 Water Framework Directive

The Water Framework Directive (WFD) (2000/60/EEC) establishes a framework for the management and protection of Europe's water resources. It came into force in 2000 and is implemented in England and Wales through the Water Environment (WFD) (England and Wales) Regulations 2017 (the Water Framework Regulations). The overall objective of the WFD is to achieve "good ecological and good chemical status" in all inland, transitional (estuarine), coastal and ground waters.

The WFD divides rivers, lakes, lagoons, estuaries, coastal waters (out to one nautical mile from the low water mark), man-made docks and canals into a series of discrete surface water bodies. It sets ecological as well as chemical objectives for each surface water body. Ecological status is measured on a scale of high, good, moderate, poor or bad, while chemical status is measured as good or fail (i.e. failing to achieve good).

The WFD has implications for development projects, particularly in ensuring that projects do not cause deterioration in water quality. In accordance with the



requirements of the WFD, development projects must give consideration to whether the project has the potential to:

- Cause a deterioration in the reported status of a waterbody;
- Prevent the achievement of good status/potential; and
- Infringe or be in breach of other legislation.

## 9.4 Marine and Coastal Access Act

The Marine and Coastal Access Act 2009 provided the legal mechanism to help ensure clean, healthy, safe, productive and biologically diverse oceans and seas by putting in place a new system for improved management and protection of the marine and coastal environment. 'Enhancement' was not specifically mentioned in the Act.

The Act contains an amendment to the Government of Wales Act 2006 to create the Welsh Zone, which is defined as the sea adjacent to Wales that goes as far out as the British fishery limit in the Irish Sea – the median line between Wales and Ireland. Welsh Ministers were given a range of new powers for the management of this Welsh Zone, meaning that the Act devolved significant responsibility to Wales for the management of its seas.

Part 3 of the Marine Act creates a statutory system for marine planning to govern and guide a wide variety of marine activities and uses of the sea. This was previously managed and regulated on a sector-by-sector basis. The Act designated a number of Marine Planning Regions and Marine Planning Authorities responsible for developing a Marine Plan for the whole or any part of their Marine Planning Regions. The Welsh Government was designated as the planning authority for the Welsh inshore area (0-12 nautical miles) and Welsh offshore regions (12 nautical miles to the median line with Ireland).

## 9.5 UK Marine Policy Statement 2011

The UK Marine Policy Statement (MPS) provides the framework for preparing Marine Plans and taking decisions affecting the marine environment. It aims to contribute to the achievement of sustainable development in the United Kingdom marine area. It has been adopted by each of the UK's devolved administrations for the purposes of Section 44 of the Marine and Coastal Access Act 2009. This is a key step towards achieving the vision shared by the UK Administrations (UK Government, Scottish Government, Welsh Assembly Government and Northern Ireland Executive) of having 'clean, healthy, safe, productive and biologically diverse oceans and seas'.

The MPS will facilitate and support the formulation of Marine Plans, ensuring that marine resources are used in a sustainable way in line with the high level marine objectives and thereby:

- Promote sustainable economic development;
- Enable the UK's move towards a low-carbon economy, in order to mitigate the causes of climate change and ocean acidification and adapt to their effects;

- Ensure a sustainable marine environment which promotes healthy, functioning marine ecosystems and protects marine habitats, species and our heritage assets; and
- Contribute to the societal benefits of the marine area, including the sustainable use of marine resources to address local social and economic issues.

As one of its high level marine objectives, the Statement stated that biodiversity should be '*protected, conserved and where appropriate recovered and loss [...] halted*'. It furthermore elaborates that:

*'Marine plan authorities should be mindful that, consistent with the high level marine objectives, the UK aims to ensure:*

- *A halting and, if possible, a reversal of biodiversity loss with species and habitats operating as a part of healthy, functioning ecosystems; and*
- *The general acceptance of biodiversity's essential role in enhancing the quality of life, with its conservation becoming a natural consideration in all relevant public, private and non-governmental decisions and policies.'*

## 9.6 Wildlife & Countryside Act 1981 (as amended)

The Wildlife and Countryside Act 1981 consolidates and amends existing national legislation to implement the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and Council Directive 79/409/EEC on the conservation of wild birds (Birds Directive) in Great Britain.

The Act makes it an offence (with exception to species listed in Schedule 2) to intentionally:

- Kill, injure, or take any wild bird;
- Take, damage or destroy the nest of any wild bird while that nest is in use or being built, or
- Take or destroy an egg of any wild bird
- Kill, injure or take any wild animal listed on Schedule 5, and
- Interference with places used for shelter or protection, or intentionally disturbing animals occupying such places.

If protected species are present within the development area, then an assessment must be undertaken to identify and describe any potential impacts from the development likely to harm the protected species and/or their habitats. Where harm is likely, evidence must be submitted to show:

- How alternative designs or locations have been considered;
- How adverse effects will be avoided wherever possible;
- How unavoidable impacts will be mitigated or reduced;
- How impacts that cannot be avoided or mitigated will be compensated for (i.e. by new habitats being created).

When it is not possible to avoid affecting species, an applicant must include a mitigation strategy to remove and reduce the negative effects of the proposal and identify what risk reduction measures will be undertaken. Mitigation must be effective against the predicted impact of the proposed development on a protected species

The Act provides for the notification and confirmation of Sites of Special Scientific Interest (SSSIs). Since devolution, various variations of the Act have clarified that the functions of the Secretary of State are transferred to Welsh authorities.

## 9.7 Planning (Wales) Act

The Planning (Wales) Act 2015 introduced a statutory purpose for the planning system, and provides the legislative and policy framework to manage the use and development of land in the public interest. It improves the existing planning process to ensure the right development is located in the right place. The planning system is central to achieving sustainable development and land use in Wales.

The act sets out a series of legislative changes to deliver reform of the planning system in Wales, to ensure that it is fair, resilient and enables development. The act addresses 5 key objectives:

- a modernised framework for the delivery of planning services – the act introduces powers to allow planning applications to be made directly to Welsh Ministers in limited circumstances
- strengthening the plan led approach – the act introduces a legal basis for the preparation of a National Development Framework and Strategic Development Plans
- improved resilience – the act will allow the Welsh Ministers to direct local planning authorities to work together and for local planning authorities to be merged
- frontloading and improving the development management system – the act will introduce a statutory pre-application procedure for defined categories of planning application
- enabling effective enforcement and appeals – the act enables changes to enforcement procedures to secure prompt, meaningful action against breaches of planning control and increase the transparency and efficiency of the appeal system.

## 9.8 Environment (Wales) Act

The Environment (Wales) Act 2016 puts in place a modern statutory process to plan and manage natural resources in a joined and sustainable way.

The Environment Act helps meet the challenge of enhancing biodiversity by introducing the ‘sustainable management of natural resources’ as a new approach, which ensures that the way in which the use of, and the impacts on, our natural resources do not result in their long-term decline.

The sustainable management of natural resources therefore enables Welsh resources to be managed in a more proactive, sustainable and joined-up way. It also

helps to tackle the challenges faced and is focused on the opportunities resources provide.

Additionally, complying with the sustainable management of natural resources contributes to the seven well-being goals of the Well-Being of Future generations (Wales) Act 2015 (Section 9.8).

Under the Environment (Wales) Act (2016), all public bodies in Wales are required to:

- Maintain and enhance biodiversity when carrying out their responsibilities and in doing so promote the resilience of ecosystems
- Demonstrate an ecosystem approach by applying the principles set out in the Act
- Prepare and publish a plan outlining how they intend to fulfil the duty
- Publish a report, every three years, on the actions which they have taken to meet this duty.

As part of the Environment (Wales) Act, a State of Natural Resources Report should be published by NRW each year, outlining policies on how natural resources can be sustainably managed, allowing Welsh Government to use the most up-to-date information to inform policies.

The National Natural Resources Policy will also set the context for area statements produced by NRW, ensuring that the national priorities for sustainable management of natural resources inform the approach to local delivery (Welsh Government 2016).

The State of Natural Resources Report will additionally be used by public authorities in complying with their new biodiversity duty, Section 6 of the Environment (Wales) Act 2016.

Sections 3, 4, 6 and 7 of the Act are the key sections which are of relevance to 'enhancement'. Section 3 on the 'Sustainable management of natural resources' notes that objective is to

*'maintain and enhance the resilience of ecosystems and the benefits they provide and, in so doing—*

*(a) meet the needs of present generations of people without compromising the ability of future generations to meet their needs, and*

*(b) contribute to the achievement of the well-being goals in section 4 of the Well-being of Future Generations (Wales) Act 2015 (anaw 2).'*

Section 4 sets out principles for the sustainable management of natural resources.

Section 6 'enhanced biodiversity and resilience of ecosystems duty' requires that Public Authorities seek to maintain and enhance biodiversity so far as is consistent with the proper exercise of their functions and in so doing promote the resilience of ecosystems. Figure 18 shows the linkages between the legislation and policy in the development of the duty plan.

A public authority, in complying with the Section 6 duty, must have regard to:

- The Section 7 list of habitats and species of principle importance for Wales;
- The State of Nature Report published by Natural Resources Wales (NRW); and
- Any area statement which covers all or part of the area in which the authority exercises its functions, once these are produced.

Section 7 replaces the duty in section 42 of the NERC Act 2006. Under Section 7 Welsh Ministers will publish lists of living organisms and habitats in Wales, which they consider are of key significance to sustain and improve biodiversity in relation to Wales. They must also take all reasonable steps to maintain and enhance the species and habitat included in any list published under this section and encourage others to take such steps.



Source: Flintshire County Council (2016)

Figure 18. The legislation and policy surrounding the Biodiversity and Ecosystem Resilience Duty delivery plan

A few examples of what public authorities could do to meet the biodiversity duty are:

- Look for opportunities, to encourage biodiversity – e.g. plant native species, wildflower areas for pollinators; and improving connectivity between valuable habitats;
- Think about how enhancing biodiversity can be incorporated in to organisation’s activities. For example, green roofs help to provide wildlife habitats, reduce energy consumption, or improve drainage systems.

For example, in the Flintshire County Council biodiversity and resilience of ecosystems duty plan, they aim to reduce pressures on habitats and species related to reduced habitat options in new builds and building maintenance and reduce development pressures through continued ecologist advice and guidance notes (Flintshire County Council, 2016).

## 9.9 Wellbeing of Future Generations (Wales) Act

The Well-being of Future Generations (Wales) Act 2015 is about improving the social, economic, environmental and cultural well-being of Wales. It places seven well-being goals into law, requiring public bodies to apply the sustainable development principles.

- 1) A prosperous Wales - an innovative, productive and low carbon society which recognises the limits of the global environment and therefore uses resources efficiently and proportionately.
- 2) A resilient Wales - a nation which maintains and enhances a biodiverse natural environment with healthy functioning ecosystems that support social, economic and ecological resilience and the capacity to adapt to change.
- 3) A healthier Wales - a society in which people’s physical and mental well-being is maximised and in which choices and behaviours that benefit future health are understood.
- 4) A more equal Wales - A society that enables people to fulfil their potential no matter what their background or circumstances
- 5) A Wales of cohesive communities - attractive, viable, safe and well-connected communities.
- 6) A Wales of vibrant culture and thriving Welsh language - a society that promotes and protects culture, heritage and the Welsh language, and which encourages people to participate in the arts and sports and recreation.
- 7) A globally responsible Wales - a nation which, when doing anything to improve the economic, social, environmental and cultural well-being of Wales, takes account of whether doing such a thing may make a positive contribution to global well-being

Under the Wellbeing of future generations (Wales) Act (2015), all public bodies in Wales are required to;

- Carry out sustainable development by demonstrating the five ways of working, any plan or project must demonstrate that they are following these ways of working.
- Publish well-being objectives which maximise its contribution to the 7 well-being goals set out in the Act

The Act establishes a statutory Future Generations Commissioner for Wales to support the public bodies listed in the Act to work towards achieving the well-being goals. The Act also establishes Public Services Boards (PSBs) for each local authority area in Wales. PSBs are tasked with improving the economic, social, environmental and cultural well-being of its area by working to achieve the well-being goals.

## 9.10 The Nature Recovery Action Plan for Wales

The Welsh Government published the national biodiversity strategy “The Nature Recovery Action Plan for Wales” in 2015 with the ambition to “halt the decline in biodiversity by 2020 and then reverse the decline, for its intrinsic value, and to ensure lasting benefits to society”. The Nature Recovery Action Plan for Wales builds on the new legislative framework and sets out how Wales will deliver the commitments of the UN convention on biological diversity, the strategic plan for biodiversity 2011-2020 and the 20 associated Aichi targets which is a short term framework for action, as well as the EU biodiversity strategy to “halt the decline in our biodiversity by 2020 and then reverse that decline”.

The Nature Recovery Action Plan focusses on 6 objectives for nature recovery in Wales, actions to reverse the decline of biodiversity are set out under each objective.

- Objective 1: Engage and support participation and understanding to embed biodiversity throughout decision making at all levels.
- Objective 2: Safeguard species and habitats of principal importance and improve their management
- Objective 3: Increase the resilience of our natural environment by restoring degraded habitats and habitat creation
- Objective 4: Tackle key pressures on species and habitats
- Objective 5: Improve our evidence, understanding and monitoring
- Objective 6: Put in place a framework of governance and support for delivery

The actions are allocated to specific partners including public bodies and local nature partnerships who are considered key partners for delivery. Welsh Government guidance states that public bodies should consider using the Nature Recovery Action Plan on which to base a biodiversity and ecosystem resilience duty forward plan. This duty plan is required by the Environment (Wales) Act (2016) (Section 9.8) and is based on the Nature Recovery Action Plan objectives, it will also help public bodies to achieve their well-being objectives which are a requirement of the Well-being of Future Generations Act (2015).

## 9.11 National Planning Policy Wales

Planning Policy Wales (PPW) sets out the land use planning policies of the Welsh Government. It is supplemented by a series of Technical Advice Notes (TANs), Welsh Government Circulars, and policy clarification letters, which together with PPW provide the national planning policy framework for Wales.

The primary objective of PPW is to ensure that the planning system contributes towards the delivery of sustainable development and improves the social, economic, environmental and cultural well-being of Wales, as required by the Planning (Wales) Act 2015, the Well-being of Future Generations (Wales) Act 2015 and other key legislation (Welsh Government, 2018).

PPW and the National Development Framework (NDF) (currently in consultation) set out how the planning system at a national, regional and local level can assist in delivering these requirements through Strategic Development Plans (SDPs) and Local Development Plans (LDPs).

The Planning Act requires the Welsh Ministers to produce and keep up-to-date the NDF, which must cover a 20-year period. The NDF concentrates on development and land use issues of national significance, indicating areas of major opportunities and change, highlighting areas that need protecting and enhancing and helping to co-ordinate the delivery of Welsh Government policies to maximise positive outcomes.

As part of the planning policy, five key planning principles have been adopted;

1. Growing our economy in a sustainable manner;
2. Making best use of resources;
3. Facilitating accessible and health environments;
4. Creating and sustaining communities; and
5. Maximising environmental protection and limiting environmental impact.

Under principle five, 'Maximising environmental protection and limiting environmental impact', it states that: '*Natural, historic and cultural assets must be protected, promoted, conserved and enhanced. Negative environmental impacts should be avoided [...]. The polluter pays principle applies where pollution cannot be prevented and applying the precautionary principle ensures cost effective measures to prevent environmental damage*' (Welsh Government, 2018).

## 9.12 Town and Country Planning Act s106 agreements

The Town and Country Planning Act 1990 regulates the development of land in England and Wales. It is a central part of land law in that it concerns town and country planning in the United Kingdom. The Planning (Wales) Act 2015 amended the Town and Country Planning Act for Wales.

In Wales, the Welsh Office Circular 13/97: Planning Obligations, sets out the Welsh Government's policy for the use of planning obligations (Welsh Office, 1997). The Planning Officers' Society for Wales has produced guidance on the use of Section



106 agreements for Welsh local authorities (Planning Officers Society for Wales, 2008).

Section 106 of the Act allows for local planning authorities (LPAs) and persons interested in land to agree contributions, arrangements and restrictions as Planning Agreements or Planning Obligations. They are commonly used to bring development in line with the objectives of sustainable development as articulated through the relevant local, regional and national planning policies.

Such agreements require developers to carry out specified planning obligations when implementing planning permissions. An agreement may be entered into to prescribe the nature of development, to secure a contribution from a developer to compensate for any loss or damage caused by a development, or to mitigate a development's wider impact (Welsh Assembly, 2015).

Obligations can be delivered either by providing what is needed to a standard set out in the agreement, examples could include providing direct site access, flood protection and wildlife protection measures and on-site leisure provision such as open space, or by paying a sum to the LPA which will then itself provide the facility, or by a combination of both.

### 9.13 UK Government's 25 Year Environment Plan

The 25 Year Environment Plan sets out the UK government's action to help the natural world regain and retain good health. It aims to deliver cleaner air and water in cities and rural landscapes, protect threatened species and provide richer wildlife habitats.

The plan policies include:

- Using and managing land sustainably.
- Recovering nature and enhancing the beauty of landscapes.
- Connecting people with the environment to improve health and wellbeing.
- Increasing resource efficiency, and reducing pollution and waste.
- Securing clean, productive and biologically diverse seas and oceans.
- Protecting and improving the global environment.

Similarly, the 25 Year Environment Plan aims to boost productivity by enhancing natural capital assets. The UK intends to use a 'natural capital' approach as a tool to help make key choices and long-term decisions.

The Plan sets out policies which will protect and enhance the environment. At sea, this will be achieved by:

- Reversing the loss of marine biodiversity and, where practicable, restoring it.
- Increasing the proportion of protected and well-managed seas, and better managing existing protected sites.
- Making sure populations of key species are sustainable with appropriate age structures.

- Ensuring seafloor habitats are productive and sufficiently extensive to support healthy, sustainable ecosystems.

These policies will embed an ‘environmental net gain’ principle for development, including housing and infrastructure to deliver environmental improvements locally and nationally.

### 9.14 UK Government Natural Environment White Paper 2011

The UK Government's white paper (HM Government, 2011) states that “past action has often taken place on too small a scale. We want to promote an ambitious, integrated approach, creating a resilient ecological network across England. We will move from net biodiversity loss to net gain, by supporting healthy, well-functioning ecosystems and coherent ecological networks”.

It notes that “achieving this will require a fundamental shift in approaches to conservation and land management.” Among the commitments made in the paper, several specifically address large-scale conservation and ecological networks (HM Government, 2011).

### 9.15 UK Natural Capital Committee annual reports.

The Natural Capital Committee (NCC) have produced a series of annual reports which provide research and advice to government on improving the natural environment.

In their 2015 Annual Report the Committee urged the Government to develop a 25-year plan for improving the natural environment and restoring its capital. In their 2017 Annual Report, the Committee emphasised the importance of rapid progress in developing and delivering this plan if the Government's aims of this being the first generation to leave the environment in a better state than the one it inherited were to be met against a backdrop of falling stocks of national natural capital (NCC, 2018).

The report proposed a series of goals for the Plan, these included:

- Wild species and habitats are thriving, and populations are restored and enhanced to levels that are sustainable into the future despite the challenges from climate change and increasing pressures from built infrastructure.
- Soils are healthy, productive and managed sustainably. All historic contaminated land is cleaned up.
- The country makes a net positive contribution to the global environment, including being among the leading nations in terms of contribution to global environmental commitments and an ever-decreasing international impact.
- All development and the use of renewable and non-renewable resources are managed in ways that result in an overall net increase in natural capital.

In January 2018 the Government published the 25-year Environmental Plan to meet these objectives (see above).

The NCCs most recent report (NCC, 2018) advises that locally and nationally significant natural capital assets need to be identified with a view to compiling an asset register. This could be a balance sheet of assets, liabilities, capital maintenance required to maintain the assets and the dependencies between assets.

To do this, the Committee will make use of appropriate knowledge, tools and techniques to ensure natural capital can be properly and consistently assessed, valued and accounted for in decision-making and economic planning. The Committee will also advise the National Infrastructure Commission to ensure that 'green and blue infrastructure' is appropriately considered within wider infrastructure discussions.

## 9.16 Environmental Liability Directive

The Environmental Liability Directive aims to make those causing damage to the environment (water, land and nature) legally and financially responsible for that damage. The Directive was adopted in April 2004. It addresses only damage and damaging events which occur after the deadline for transposition at Member States level, i.e. 30 April 2007.

The purpose of the Environmental Liability Directive (ELD) is to establish a framework of environmental liability, based on the "polluter-pays" principle, to prevent and remedy environmental damage.

There are three categories of environmental damage under the ELD:

- Damage to protected species and natural habitats - any damage that has significant adverse effects on reaching or maintaining the favourable conservation status of such habitats or species. The habitats and species concerned are defined by the Birds Directive 79/409 and the Habitats Directive 92/43;
- Water damage - any damage that significantly adversely affects the ecological, chemical and/or quantitative status and/or ecological potential, as defined in the Water Framework Directive 2000/60; and
- Land damage - any land contamination that creates a significant risk of human health being adversely affected as a result of the direct or indirect introduction, in, on or under land, of substances, preparations, organisms or micro-organisms.

Competent authorities will be in charge of specific tasks, such as assessing the significance of the damage and determining which remedial measures should be taken.

Where environmental damage has not yet occurred but there is an imminent threat of such damage occurring, the operator shall take the necessary preventive measures and inform the competent authority of the situation, as soon as possible. Where environmental damage has occurred, the operator shall take all practicable steps to immediately control, contain, remove or manage the relevant damage factors in order to limit or prevent further environmental damage and adverse effects on human health, and the necessary remedial measures, in accordance with the relevant provisions of the ELD.

Remedying of environmental damage, in relation to water or protected species or natural habitats, is achieved through the restoration of the environment to its baseline condition.

The ELD aims at ensuring that the environment be physically reinstated. This is achieved through the replacement of the damaged natural resources by identical, equivalent, or similar natural components, or, as appropriate, by the acquisition/creation of new natural components. If measures taken on the affected site do not allow achieving the return to the baseline condition, complementary measures may be taken elsewhere (for instance, an adjacent site).

The ELD is transposed into English and Welsh legislation via the 'Environmental Damage (Prevention and Remediation) Regulations 2009'.

## 9.17 Legislation, policy and guidance summary

Table 7 below summarises key European, UK and Welsh instruments which can be used to support ecological enhancement and closely related measures.

**Table 7. Summary of European and UK legal instruments that can be used to support ecological enhancement**

Legal framework	Salient points
European (UK transposition of) Convention on Biological Diversity (CBD)	Under CBD COP10, signatories are committed to objectives to integrate biodiversity values into all planning processes, to address the underlying causes of biodiversity loss and reducing (as close as possible to zero) the degradation of natural habitats. Ecological enhancement can assist meeting these requirements.  Taken account of in the Nature Recovery Action Plan for Wales' in 2015.
EC Water Framework Directive (2000/60/EEC)	A key legal framework under which ecological enhancements are delivered.
EIA Directive (2011/92/EU EIA), as amended by the EIA Directive (2014/52/EU)	A key legal framework under which ecological enhancements are delivered.
Strategic Environmental Assessment Directive (2001/42/EC), and 2004 UK Regulations	The Directive clearly provides opportunities for consideration of measures to enhance as well as mitigate against significant impacts on the environment.
The Marine Strategy Framework Directive (Directive 2008/56/EC)	The Directive requires member states to achieve 'Good Environmental Status' in European seas by 2020. In addition to setting environmental targets and monitoring programmes, 'corrective measures' are required to ensure good status. Delivery of ecological enhancements can help achieve this.

Legal framework	Salient points
Habitats Directive 92/43/EEC & Birds Directive 79/409/EEC	Directive provides a hierarchy of avoidance, mitigation and compensation. Intertidal rocky habitats and species are not, however, included within the Annexes of the Directives, but ecological enhancement can nevertheless support maintenance of ecological connectivity (Article 10), and structures such as harbour walls and wind farms may offer opportunities for seabird conservation.
Marine and Coastal Access Act 2009 (England and Wales)	A system of biodiversity objectives and offsets could see the need for enhancement measures to be retrofitted or delivered through Marine Plans.
Wildlife & Countryside Act 1981 (as amended)	If protected species are present within the development area, then an assessment must be undertaken to identify and when it is not possible to avoid affecting species an applicant must include a mitigation strategy.
Environment (Wales) Act 2016	Sets out the 'sustainable management of natural resources'. Section 6 of the Act requires public authorities to seek to ' <i>maintain and enhance biodiversity [...] in the exercise of their functions</i> '. Section 7 requires Welsh Ministers to ' <i>take all reasonable steps to maintain and enhance the living organisms and types of habitat included in any list published under this section and encourage others to take such steps</i> '.
Wellbeing and Future Generations (Wales) Act	Improving the social, economic, environmental and cultural well-being of Wales. Resilient Wales' goal, aims to create ' <i>A nation which maintains and enhances a biodiverse natural environment with healthy functioning ecosystems that support social, economic and ecological resilience and the capacity to adapt to change (for example climate change)</i> '.
Planning Policy Wales	States that the planning system should contribute to the delivery of sustainable development and improve the social, economic, environmental and cultural well-being of Wales and includes specific policies on conserving and enhancing the natural environment through planning. ' <i>Natural, historic and cultural assets must be protected, promoted, conserved and enhanced. Negative environmental impacts should be avoided</i> '. Accompanied by Technical Advice Notes (TANs), e.g. TAN 5, <i>Nature Conservation and Planning (2009)</i> .
UK Government's 25 Year Environment Plan	Environmental Net Gain – 'to deliver environmental improvements locally and nationally', by 'recovering nature and enhancing the beauty of landscapes'
Town and Country Planning Act 1990 (as amended) Section 106 agreements	An agreement may be entered into to prescribe the nature of development, to secure a contribution from a developer to compensate for any loss or damage caused by a development, or to mitigate a development's wider impact. Ecological enhancement can assist meeting these requirements.
Countryside and Rights of Way (CROW) Act 2000	Supports habitat protection and enhancement, and places a requirement on local authorities to have regard for biological conservation and enhancement in planning.
Harbour Revision Orders (Harbours Act, 1964)	Ecological enhancements may be required as part of these permissions. Enhancements may be required to overcome holding objections made by statutory consultees during an application's consultation process for example.

## 10 Appendix B – Welsh Coastal and Marine Species and Habitats listed as being of principal importance

For this Appendix, the relevant marine and coastal species and habitats have been extracted from the lists available on the Wales Biodiversity Partnership Website, and are listed in Table 8 and Table 9.

Table 8. Marine and coastal species listed as being of principal importance in Wales

Species	
Cnidaria	
<i>Eunicella verrucosa</i>	Pink sea-fan
<i>Haliclystus auricula</i>	A stalked jellyfish
<i>Lucernariopsis campanulata</i>	A stalked jellyfish
Coastal and marine Birds	
<i>Anser albifrons subsp. flavirostris</i>	Greenland greater Whitefronted Goose
<i>Branta bernicula subsp. bernicula</i>	Dark-bellied Brent Goose
<i>Charadrius hiaticula</i>	Ringed Plover
<i>Cygnus columbianus subsp.</i>	Bewick's Swan
<i>Larus argentatus subsp. argenteus</i>	Herring Gull
<i>Larus ridibundus</i>	Black-headed Gull
<i>Limosa lapponica</i>	Bar-tailed Godwit
<i>Numenius arquata</i>	Eurasian Curlew
<i>Pluvialis apricaria</i>	Golden Plover
<i>Puffinus mauretanicus</i>	Balearic Shearwater
<i>Sterna dougallii</i>	Roseate Tern
Fish	
<i>Alosa alosa</i>	Allis shad
<i>Alosa fallax</i>	Twaite shad
<i>Ammodytes marinus</i>	Sand-eel
<i>Anguilla anguilla</i>	European eel
<i>Clupea harengus</i>	Herring
<i>Dipturus batis</i>	Common skate
<i>Gadus morhua</i>	Cod
<i>Galeorhinus galeus</i>	Tope shark
<i>Hippocampus guttulatus</i>	Long snouted seahorse
<i>Lamna nasus</i>	Porbeagle shark
<i>Lophius piscatorius</i>	Sea monkfish
<i>Merlangius merlangus</i>	Whiting
<i>Merluccius merluccius</i>	European hake
<i>Molva molva</i>	Ling
<i>Osmerus eperlanus</i>	Smelt (Sparling)
<i>Palinurus elephas</i>	Crayfish, crawfish or spiny lobster
<i>Petromyzon marinus</i>	Sea lamprey
<i>Pleuronectes platessa</i>	Plaice
<i>Prionace glauca</i>	Blue shark
<i>Raja brachyura</i>	Blonde ray
<i>Raja clavata</i>	Thornback ray
<i>Raja undulata</i>	Undulate ray
<i>Rostroraja alba</i>	White or Bottlenosed skate
<i>Salmo salar</i>	Atlantic salmon
<i>Salmo trutta</i>	Brown/Sea trout
<i>Salvelinus alpinus</i>	Arctic char
<i>Scomber scombrus</i>	Mackerel
<i>Solea solea</i>	Sole

Species	
<i>Squalus acanthias</i>	Spiny dogfish
<i>Squatina squatina</i>	Angel shark
<i>Trachurus trachurus</i>	Horse mackerel
Invertebrates	
<i>Alkmaria romijni</i>	Tentacled lagoon worm
<i>Arctica islandica</i>	Icelandic cyprine or Oceanquahog
<i>Atrina fragilis</i>	Fan mussel
<i>Edwardsia timida</i>	Burrowing anemone
<i>Ostrea edulis</i>	Native oyster
<i>Tenellia adspersa</i>	Lagoon sea slug
Mammals and turtles	
<i>Balaenoptera acutorostrata</i>	Minke whale
<i>Balaenoptera physalus</i>	Fin whale
<i>Caretta caretta</i>	Loggerhead turtle
<i>Cetorhinus maximus</i>	Basking shark
<i>Delphinus delphis</i>	Common dolphin
<i>Dermochelys coriacea</i>	Leatherback turtle
<i>Globicephala melas</i>	Long-finned pilot whale
<i>Grampus griseus</i>	Risso's dolphin
<i>Hyperodon ampullatus</i>	Northern bottlenose whale
<i>Lagenorhynchus acutus</i>	Atlantic white-sided dolphin
<i>Lagenorhynchus albirostris</i>	White-beaked dolphin
<i>Megaptera novaeangliae</i>	Humpback whale
<i>Orcinus orca</i>	Killer whale
<i>Phocoena phocoena</i>	Harbour porpoise
<i>Stenella coeruleoalba</i>	Striped dolphin
<i>Tursiops truncatus</i>	Bottlenose dolphin
<i>Ziphius cavirostris</i>	Cuvier's beaked whale
Plants	
<i>Anotrichium barbatum</i>	Bearded red seaweed
<i>Cruoria cruoriaeformis</i>	A red seaweed
<i>Dermocorynus montagnei</i>	A red seaweed
<i>Lithothamnion corallinoides</i>	Coral maerl
<i>Padina pavonica</i>	Peacock's tail
<i>Phymatolithon calcareum</i>	Common maerl

Table 9. Marine and coastal habitats listed as being of principal importance in Wales

Category	Habitat Name
Littoral Rock	Intertidal boulder communities
	<i>Sabellaria alveolata</i> reefs
	Estuarine rocky habitats
Littoral sediment	Intertidal boulder communities
	Intertidal mudflats
	Seagrass beds
	Sheltered muddy gravels
	Peat and clay exposures
Sublittoral rock	Coastal saltmarsh
	Fragile sponge & anthozoan communities on subtidal rocky habitats
	Carbonate reefs
Sublittoral sediment	Tidal swept channels
	Subtidal mixed muddy sediments
	Mud habitats in deep water
	<i>Musculus discors</i> beds
	Blue mussel beds
	Horse mussel beds
	Maerl beds
	Saline lagoons
Subtidal sands and gravels	
Supralittoral rock	Maritime cliff and slopes
Supralittoral sediment	Coastal sand dunes
	Coastal vegetated shingle
Improved grassland	Coastal and floodplain grazing marsh



## 11 Appendix C – Case Studies for Ecological Enhancement Opportunities

This Appendix provides further detail on case studies discussed in Section 4. The case studies are structures according to the following categories:

- Enhancement of existing artificial structures;
- Intertidal habitat creation/restoration;
- Fish and bird enhancements;
- Other habitat modification measures; and
- Offsite measures.

### 11.1 Enhancement of Artificial Structures

In this section, case studies are sorted into the following categories:

- Vertical structures;
- Rock armouring; and
- Marine scour protection.

#### 11.1.1 Vertical structures

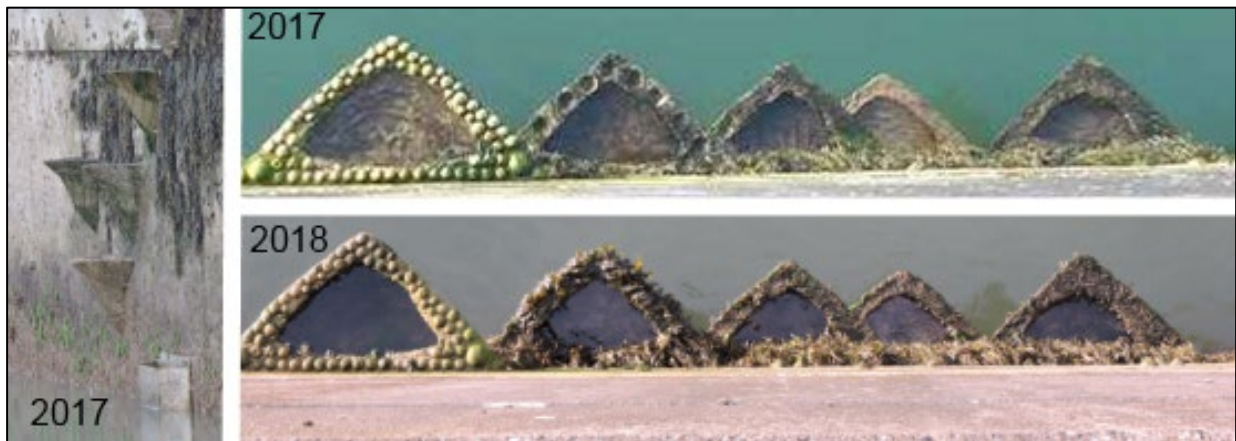
##### 11.1.1.1 *Retrofitting case studies*

#### **Vertipools, Isle of Wight, England**

On the Isle of Wight, so-called vertipools were first installed in 2013, as part of a project called ‘shelving the coast’. Then, five vertipools were installed along the seawall at Bouldner (Ecclestone George, undated). Further projects have since been completed, including at Compton and Fishbourne on the Isle of Wight. The company behind the vertipools, Artecology work with Bournemouth University to evaluate and enhance these structures and are continuing to work on new designs and models (Artecology, 2018).

The array at Fishbourne involved the installation of six vertipools at the Wightlink ferry quay wall. The vertipools were installed in August 2017 at different tidal heights between mean high and low water, designed to provide areas of standing water to increase biodiversity across the site (see Copyright: ABPmer Figure 19). These vertipools were included in the project to, amongst others, offset small scale non-designated mudflat losses due to piling (requested by the Environment Agency to achieve a no net loss of the mudflat priority habitat).

Five of these pools were made of concrete and were sculpted in bespoke moulds that had complex and varying external textures. Another pool had a unique trough-like design with a stainless steel wall and shingle base. The latter was intended to mimic mudflat habitat, and the shingle base was thus topped with mud, and the trough installed at a low tidal elevation equal to that of adjacent mudflat. However, the muddy materials were washed out after a few tides, and only the shingle base now remains.



Copyright: ABPmer

Figure 19. The vertipools at Fishbourne (with the steel trough only visible in the vertical image on the left) (Isle of Wight, England)

Naylor *et al.* (2017) quote a case study whereby the incorporation of 50 vertipools for 100 m of seawall was estimated to cost approximately £300 per m, or approximately £600 per vertipool. Wightlink have declined to share their cost information for the purpose of this report. . The creators of the Vertipools. Isle of Wight based company Artecology quote per-unit costs of between £175 and £500, excluding tax and installation (pers. comm., Artecology/ABPmer, January 2019). Installation costs can be highly variable, depending on the accessibility and nature of the installation site. Artecology advise that just under 100 vertipools had been installed across the UK by January 2019.

### **‘Flowerpots’, Sydney Harbour, Australia**

Further afield, in Sydney Harbour, flowerpots were retrofitted to seawalls to introduce artificial rock pool structures to the seawall (Figure 20) (Strain *et al.*, 2017). In total, 80 flowerpots were installed in 2015, at \$300 each (around £170 in 2017 prices).



Source: Strain *et al.*, 2017

Figure 20. Custom-made ‘flowerpots’ retrofitted to Sydney Harbour (Australia) seawall (close up of cushion star and luderick fish found in some pots on right)

### 11.1.1.2 *New construction case studies*

#### **Recessed rockpools in sandstone seawall, Sydney Harbour, Australia**

The opportunity for ecological enhancement as part of the planned replacement of vertical sandstone walls in Sydney Harbour was recognised at a pre-planning stage by key individuals. This resulted in the design of artificial ‘rockpools’, which were created through the inclusion of small cavities in the vertical sandstone wall during construction in 2009 (Figure 21).

Post-construction monitoring found that invertebrate species richness was increased after 1 year, with pool biodiversity greater than adjacent walls (Naylor *et al.*, 2011).



Source: Naylor *et al.*, 2011

Figure 21. Artificial pools in a vertical sandstone wall, Sydney Harbour (Australia)

#### **Inclusion of niche habitats in new tidal defences, Shaldon and Ringmoor, Devon, England**

The Shaldon and Ringmore £6.5 million tidal defence scheme was built in 2010/2011 to provide flood protection to the homes and businesses of the villages in Devon, UK (Naylor *et al.*, 2011).

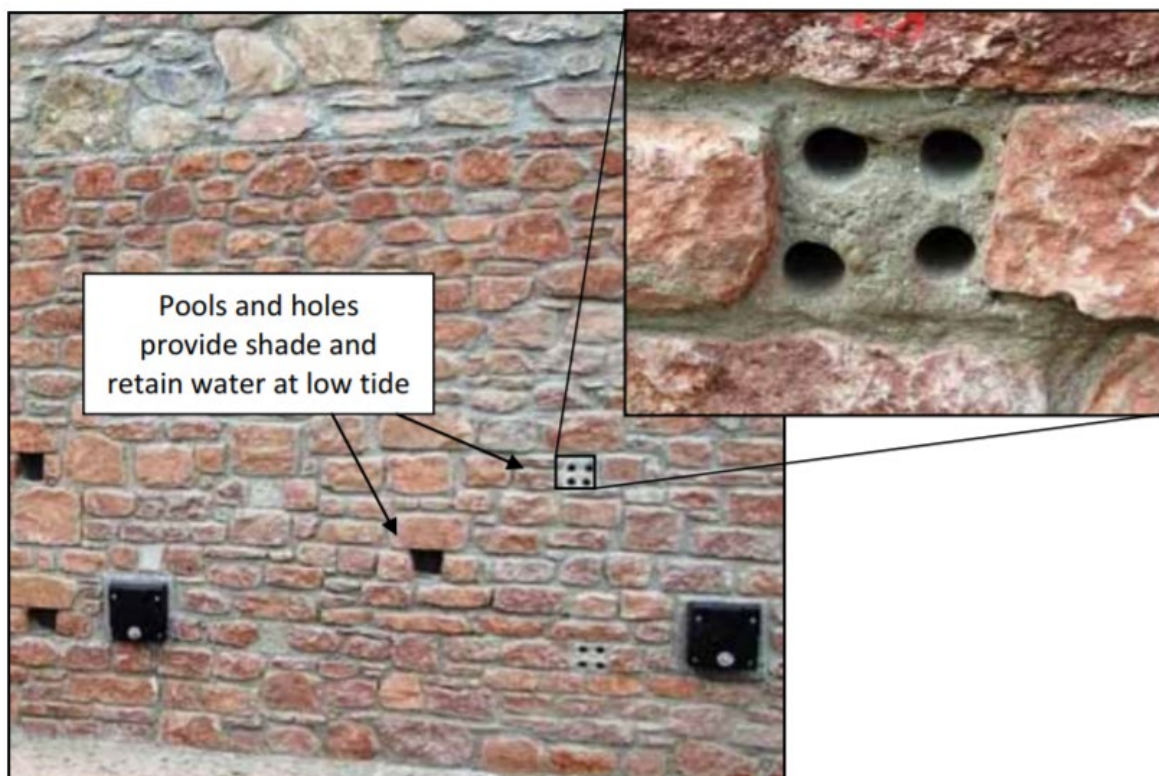
The development required ecological enhancements to be incorporated in the final design, in accordance with the submitted Environmental Report. The latter proposed “to deliver new niche habitats built into the lower sections of some of the walls to enable marine life to colonise within them”. Designs were finalised during detailed design, and revisited and adapted during construction.

A trial was designed to test different enhancement options in the development (Figure 22), these included:

- Grooves: Mortar was roughened by 'drawing' grooves (mm in size) in the wet mortar during construction. This was based on previous work showing positive responses of barnacles to similar features on concrete.
- Holes: Holes (1.5 cm diameter) were made in wet mortar using a broom handle to create shaded, water retaining features known to be important for marine organisms including limpets. Four holes were made in each section of mortar.
- Pools: Recessed areas were created by occasionally leaving out blocks in the wall and creating a pool at the base of the recess by inserting a sand-filled bag in the wet mortar which was later removed.

The estimated cost of creating the trial was £20,000; this represents 0.3% of the total scheme cost.

Early observations suggested that the treatments are being colonised by cyanobacteria and foliose algae, and that macro-fauna (snails and limpets) are responding positively to the enhancements.



Source: Naylor *et al.*, 2011

Figure 22. Structure enhancement during construction of Shaldon and Ringmore Tidal Defence Scheme (Devon, England)

### 11.1.2 Rock armouring

#### **'Passively' enhanced rock revetment, Hartlepool coastal defence, County Durham, England**

This scheme aimed to upgrade the defences at Hartlepool in line with the shoreline management plan, which supports the natural development of the SPA and Ramsar coastal habitat at the site.

Phase 1 of the development consisted to 800 m of low-level granite rock revetment to dissipate wave energy and protect the toe of deteriorated sections of existing seawall, whilst also aiming to 'provide the same ecological function for overwintering birds'. As such, the aim was for there to be no overall loss of habitat function for Annex II bird species.

A mix of 'passive' techniques (e.g. choosing construction materials based on lithology and surface roughness) and more 'active' multi-scale enhancements that sought to mimic the heterogeneity of natural rocky shores were utilised (e.g. rock and concrete blocks with fine-scale textures, incorporation of sheltered and overhanging areas and water-retaining features such as pools). For the active enhancement, it cost an extra £8-£30 per m<sup>2</sup> compared to plain cast formwork. Extensive discussions between the design team, scientists and the construction team 'ensured benefits were maximised and engineering function was not compromised within the project's budget'

Preliminary results showed that the new 'passively' enhanced rock revetment (involving informed selection and placement of armour units to maximise the physical complexity of the structure) produced the same biotope as the baseline natural shore platform. Importantly, the enhanced areas had higher species densities of key prey species for birds (e.g. limpet abundance) than the partially enhanced areas. The enhanced areas also supported quicker succession and had species densities more similar to baseline conditions than partially enhanced areas of the revetment. These ecological enhancements helped mitigate ecological impacts of the new rock revetments, over timescales as short as 18 months (Naylor *et al.*, 2017b).

#### **Tide pool module integration into rock armour/riprap, Brooklyn, New York, United States**

In 2013, as part of flood defence works at Brooklyn Bridge Park, four EConcrete® precast tide pools which were integrated between rip rap stones in order to increase the biological productivity of the newly constructed beach (see Figure 23). Nine months after installation (August 2014), and after a 'long harsh winter during which the pools were iced', monitoring revealed that the pools presented 89 to 100% live cover and higher biodiversity, 'in stark contrast to the very poor biological function of the surrounding riprap rock' (EConcrete, 2016). As noted above in Section 4.2.1, in the UK, these retail at £990 per unit (excluding tax/installation) (pers. comm. Moore Concrete Products Ltd / ABPmer, February 2019).



Source: EConcrete, 2016

Figure 23. Tide pools installed amongst rock armouring/rip rap in New York (US)

### 11.1.3 Marine scour protection

#### Bureau Waardenburg (Dutch) review study

Bureau Waardenburg (2017) assessed different eco-friendly designs for enhancement of scour protection for offshore wind farm developments in the North Sea. Different options presented as part of the study considered a mixture of large structures which provide holes, smaller-scale structures to provide habitat complexity and materials that provide or mimic natural substrates. Table 10 provides some cost estimates of example materials. Figure 24 shows a range of options presented in the study which could be utilised for offshore wind enhancement.

Table 10. Cost indications of some example materials for inclusion in offshore wind scour protection enhancement.

Treatment	Example material	Approx. size	Price per unit (€) (and £ in 2018 prices, rounded)	No. per monopile	Cost per monopile (€)
Large structures	Reef balls	2m	1000 (£900)	50	50,000
	Xblock	2-3m (4m <sup>3</sup> )	800 (£700)	50	40,000
Small structures	Boulders, scour gravel	-	No additional cost to conventional scour protection		
	BESE elements <sup>16</sup>	-	4 (£3.5)	500	2,000
Mimic natural substrate	Empty mussel or oyster shells	1m <sup>3</sup> units	20-100 (£17 – £90)	50	1-5,000
Active re-introduction	Live oyster cages	2m <sup>3</sup>	4,000 (£3,500)	5	20,000

The study aimed to investigate ways to optimise the scour protection of offshore wind farms and enhance ecological functioning. Enhancement of ecological functioning was defined as: increasing habitat suitability for species (or communities) occurring naturally in the Dutch North Sea, in particular, for endangered species such as listed

<sup>16</sup> BESE-elements® (Biodegradable Elements for Starting Ecosystems) is a biodegradable three-dimensional solid grid, made of starch from potato waste. <https://www.bese-elements.com/>

in the EU Habitats Directive, OSPAR or national red lists. In particular Atlantic cod and European flat oyster were highlighted as target species in this study.

Different scour protection options were tested at wind farm sites in the North Sea. At Egmond aan Zee, scour protection consisted of a filter layer of small sized rock and a top layer of heavier rock grade. Densities of species were greater on areas of heterogenous scour protection. Prinses Amalia Wind Farm scour protection of rock dump of various dimensions was utilised. The total number of species found in the scour protection layer (56) was considerably higher than found in Egmond aan Zee (35).



Source: Bureau Waardenburg, 2017

Figure 24. Examples of scour protection enhancement options

The following ‘basic design principles’ were highlighted by the authors:

- There is a difference in required scour protection layer thickness and armour rock size based on storm-induced wave loads and the dimensions and shapes of the wind turbine support structures;
- The horizontal extent of the scour protection typically scales with the monopile diameter;
- For the Dutch North Sea, the basic approach is a filter layer and an armour layer, made of natural crushed rock material (mostly Norwegian granite), so this should be observed as a baseline when valuing “added values”;
- Bed protection will also be needed on the cable crossings;
- Any innovative scour protection, or large “add-on” structures, should be tested in the lab for failures and be approved by a certifying body, before they can be applied in the field, as they can either become unstable themselves or cause neighbouring scour protection materials to become unstable under hydraulic design conditions. Mixing in <5% of other material in a standard scour lay-out is a potentially feasible option that can be tested in the field on the short term.
- Costs are lowest for materials that can be mixed in.

## 11.2 Intertidal Habitat Creation/ Restoration

### **Medmerry managed realignment, West Sussex, England**

Medmerry (see Figure 25) is the largest managed realignment of the open coast in Europe, on the stretch of coast that was most threatened by coastal flooding in South East England. As a whole the scheme is considered to be an enhancement improving the condition of the coastal SSSIs in the Solent areas, before which a larger percentage were considered unfavourable (ABPmer, 2010).

As part of the scheme, the Environment Agency built 7 km of new flood embankment on higher ground and has breached the existing defence, creating intertidal habitat to compensate for Natura 2000 loss elsewhere around the Solent. The scheme also mitigated for the loss of freshwater SSSI and the impact on important populations of protected species and created an accessible landscape-scale nature reserve in collaboration with the RSPB and the local community.

The site is now managed as an RSPB reserve. The award-winning project included the following works:

- Construction of new set back line of defence;
- Construction of rock groynes;
- Breach of shingle ridge;
- Creation of topographic variation; and
- Planning for visitor access and interpretation.

The total cost of development was £28 million but the realignment project provided effective compensation for coastal squeeze, addressed an existing problem of coastal management impacting on nationally designated features and also provided a more sustainable approach to flood risk management (Natural England, 2015).





Copyright: Channel Coastal Observatory

Figure 25. Aerial View of Medmerry Managed Realignment, September 2015 (West Sussex, England)

### **Boiler Marsh sediment recharge; Lymington, Hampshire, England**

The Boiler Marsh sediment recharge project was undertaken by Wightlink Ltd. to mitigate for the possible (and uncertain) effects on the Solent Estuary European Marine Site from the navigation of new passenger ferries between Lymington to Yarmouth. The aim of the recharge was to delay the loss of the deteriorating marsh within and surrounding the area where dredge sediments were placed.

In addition to restoring distinctive sections of the Boiler Marsh, the Wightlink Ltd project also reduced the rates at which the marsh surrounding the deposit site decays (a value calculated using a distinct 'hectare-year' metric that has been used on other Lymington projects). This was because the recharge was deliberately located at the end point of a large channel which was cutting through the marsh. Without intervention, the channel was going to soon fracture the marsh into two parts and then accelerate the rate at which the whole marsh eroded. This delay to the loss of marsh also provides benefits such as delaying the need for rock armour extension.

Maintenance dredged silt from the upper Lymington Channel and Yacht Haven were placed on an eroding area of saltmarsh ('Boiler Marsh'). The site was remote from the sediment sources, so the maintenance arisings had to be 'double handled'. They were initially dug using a back-hoe dredger and placed in 70 m<sup>3</sup> hoppers and transported to the site where they were pumped through a 100 m pipe to the deposition area. There were two campaigns in February and March 2012 and 2013.

A total of 1,330m<sup>3</sup> and 3,120m<sup>3</sup> were delivered in these two years, to restore/create 1 ha of saltmarsh habitat.

Relatively consolidate clay was also present in some hoppers and this presented challenges for moving and pumping the sediment. The pumped sediment was retained *in situ* using fences made of stakes, willow and straw. These were built across the mouth of the main (eroded) drainage channel and also at intervals throughout the area to create weir-like features and stilling basins.

This project was atypically costly. The estimated total fee for this work was £500,000 (some £560,000 in 2018 prices). This high fee was incurred for many reasons, including the need to: accommodate a rapid turnaround following a public inquiry judgement; install fencing in difficult weather conditions at locations that were difficult to access; pay fees for leasing the compound site and for berthing/mooring; incur costs for the dredge material (with these fees equating to the extra costs incurred by the on-site contractor for operating under tidal constraints as compared against the fees incurred for offshore disposal without such constraints); as well as costs for a monitoring programme and hosting and overseeing a management panel and, where required, securing legal advice (ABPmer, 2017b).

### 11.3 Fish and Bird Enhancement

#### **Morecambe Bay skear habitat creation, Morecambe, Lancashire, England**

A cobble skear habitat that was translocated in 2006 as mitigation for the loss of bird habitat under the footprint of the Morecambe Town Phase VI defences. The rocky habitat which would have been lost was excavated, translocated and repositioned in front of the breakwater, within the mitigation area (see Figure 26). In order to further maximise the potential niche diversity and invertebrate abundance on the newly created skear, the constructors were also instructed to place larger boulders on the surface of the new habitat and not to roll these in under the digger tracks.

This project successfully created a new stable skear habitat that became colonised by a typical assemblage of high shore epifaunal species (mussel and periwinkles) and was also used as mid-tide roost by waterbirds such as oystercatcher.

The ecological function in terms of offering a comparable habitat to that which was lost has been maintained and improved on, given the skear provides both a sub-roost and supplementary feeding habitat for a significant number of waterbirds. The new Sunnyslopes breakwater that was completed in 2007 has resulted in a redistribution of roosting birds along the Morecambe foreshore, with a high number of oystercatcher and redshank regularly roosting on the groyne. This is considered to be due to the closer proximity of the breakwater to their primary food source on the lower shore skears, combined with an increased disturbance at the other nearby roost sites at Battery and Regent Road.

In summary, the mitigation skear is considered a success with regards to maintaining the integrity of the Morecambe Bay European Marine Site in favourable condition (ABPmer, 2005).



Copyright: Lancaster City Council, March 2008

Figure 26. Breakwater at Morecambe (Lancashire, England) with innovative rocky habitat mitigation area in front

### **Elliot Bay Seawall project –improvements to mitigate impacts on migrating salmon, Seattle, United States**

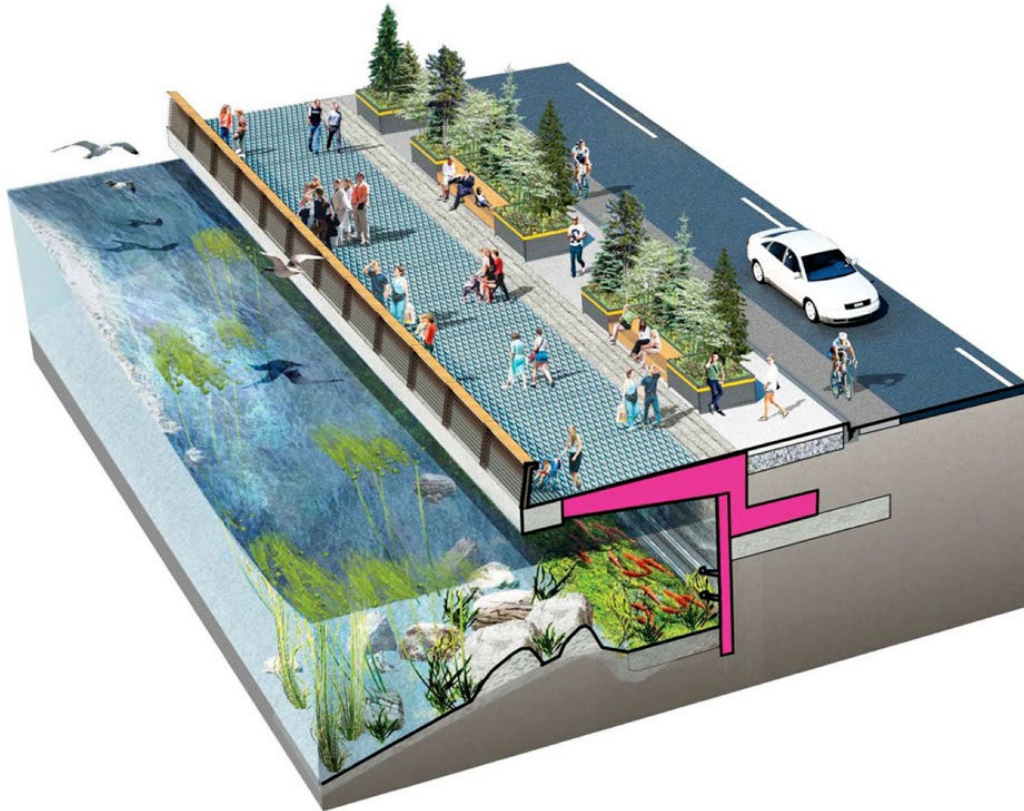
The existing sea wall at Elliott Bay, Seattle, had deteriorated from significant seismic activity and damage from wood ingesting crustaceans. As such repairs/ re-design of the structure had to be undertaken. This gave the opportunity to restore habitats lost or negatively impacted by long-term urbanisation, including salmon migration corridors.

Elliott Bay is an important juvenile salmon migration route (Duwamish River to the Pacific Ocean). However, shallow-water habitat is limited, making migration along the shoreline difficult. Over-water structures also produced intermittent dark and light areas that are problematic for small fish to negotiate. A key driver of the scheme was to improve the degraded nearshore habitat for salmon (Naylor *et al.*, 2017a).

During sea defence reconstruction the developers integrated several enhancements into the design to improve habitat conditions for native species. The most notable enhancement was the use of light-permeable materials (glass blocks and grated walkways) to reduce shading of the water column by large overwater structures that can affect feeding ability by juvenile salmon (see Figure 27). Additional measures included in the scheme were:

- (1) sediment enhancement to support plant and invertebrate colonisation;
- (2) creation of an artificial beach and placement of intertidal benches and stone-filled marine mattresses to create shallow water, low gradient habitat; and
- (3) incorporation of texture and relief into the seawall face to improve ecological potential within the intertidal and supratidal (accounting for future sea level rise).

The whole project cost approximately \$410 million. The cost of the additional enhancements was estimated to be \$20 million (around 5% of the total project cost); these were above business-as-usual costs. Post-construction monitoring of enhancement effects on local ecology is expected to cost an additional \$1M to \$2M over business-as-usual monitoring, over a 10-year period (Naylor *et al.*, 2017a).



Source: Naylor *et al.*, 2017a

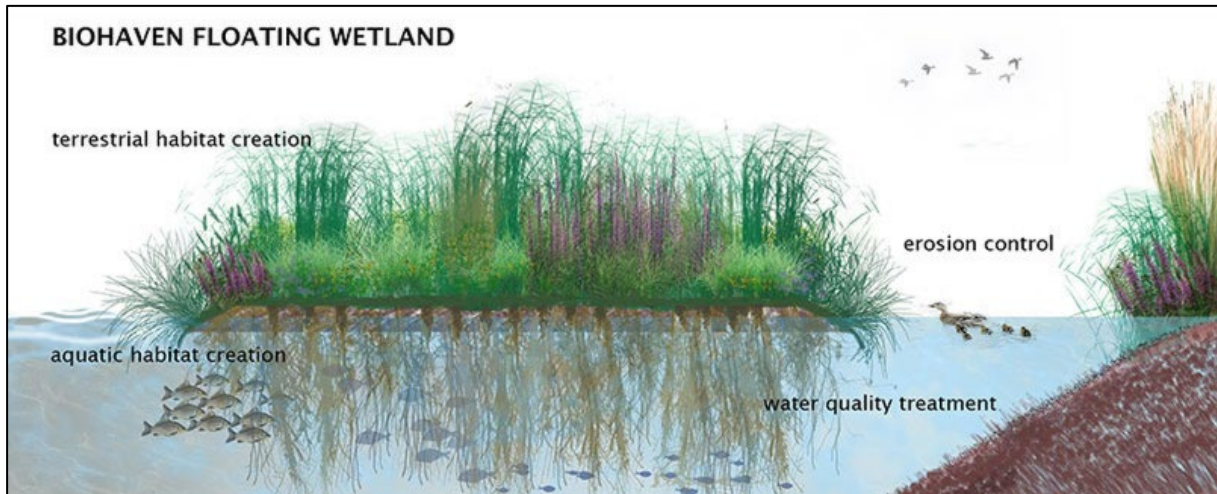
Figure 27. Proposed seawall re-development, Seattle USA

## 11.4 Other Habitat Modification

### **ABP BioHaven Wetland, Swansea Prince of Wales Dock, Swansea, Wales**

ABP Swansea have installed a BioHaven Floating Wetland in Swansea Prince of Wales Dock in a joint venture with Swansea University. The wetland was installed as an enhancement in the hope it will deliver multiple benefits for water and wildlife. Figure 28 shows the concept of BioHaven floating wetland.

The wetland can be used to not only enhance biodiversity but can also be used to create and connect habitats and offer naturalised floating erosion control to help protect and restore sensitive habitats.



Source: Frog Environmental Website [last accessed May 2019]

Figure 28. BioHaven Wetland concept

Although in the early stages the wetland habitat is already proving successful. Saltmarsh and other wetland vegetation has developed on the island and gulls, mute swans and cormorants have been seen utilising the area. In addition, juvenile sea bass regularly use the island for shelter, and due to the mussels and ascidians that have attached underneath, it is also a source of food for both fish and birds (Figure 29).



Copyright: ABP

Figure 29. Wetland Island enhancement at Swansea

## 11.5 Offsite Enhancements

### 11.5.1 LIFE Natura 2000 Wales

The LIFE Natura 2000 Programme for Wales has developed a strategic forward plan to manage and restore Natura 2000 in Wales. The purpose of the Programme was to enable Wales to make significant progress towards bringing Natura 2000 species and habitats into favourable condition and help meet its commitments under the European Habitats and Birds Directives (NRW, 2015c).

The LIFE Natura 2000 Programme for Wales was interested in quantifying the benefits provided by Natura 2000 features and sites in Wales to demonstrate their value to the economy and society.

As part of the project Thematic Action Plans (TAPs) were created to address major issues and risks. 11 TAPs were created, each of which detail priority strategic actions to address major issues and risks which have been identified as having an adverse impact on Natura 2000 features across the network.

- Access and recreation;
- Air pollution: Nitrogen deposition;
- Climate change and habitat fragmentation;
- Diffuse water pollution;
- Flood and coastal erosion risk management;
- Grazing and livestock management;
- Non-native invasive species and pathogens;
- Man-made changes to hydraulic conditions;
- Marine litter;
- Marine fisheries; and
- Woodland management.

The actions, may be delivered at national or regional level and are designed to complement site-level actions highlighted within Prioritised Improvement Plans.

Prioritised Improvement Plans (PIPs) are prioritised, costed plans which summarise the proposed actions needed by 2020 to help improve the condition of the designated habitat and species features of all Natura 2000 sites. Actions address high and medium priority issues and risks which are preventing the features from reaching favourable condition.

In total nearly 3,600 actions to address issues and risks on Natura 2000 in Wales have been logged both at a site and unit level. On average there are 32 unique actions per site. The total estimated cost is approximately £120 million (see Table 11).

Table 11. Natura 2000 actions and costs for most frequently logged issues and risks

Issues and risks	No of site-level actions	No of unit-level actions	Total no of actions	Cost of actions
Grazing and livestock management	74	1,223	1,297	£23,904,000
Invasive species (native and non-native), parasites and pathogens	154	443	597	£12,723,000
Man-made changes to hydraulic conditions	63	336	399	£18,972,000
Access and recreation management	94	187	281	£3,085,000
Woodland management	27	207	234	£4,710,000
Habitat fragmentation	55	136	191	£2,688,000
Diffuse water pollution	76	108	184	£12,909,000
Air pollution	74	4	78	£355,000
Flood and coastal erosion risk management	18	59	77	£44,157,000

### 11.5.2 Improvement Programme for England's Natura 2000 Sites (IPENS)

Similar to the PIPs above, The Improvement Programme for England's Natura 2000 sites (IPENS), was undertaken to enable Natural England, the Environment Agency, and other key partners to plan what, how, where and when to target their efforts on Natura 2000 sites in England and the areas surrounding them.

As part of the IPENS programme, themed action plans were developed, which aim to improve the way in which a key issue for the Natura 2000 network is managed. Theme plans provide an over-arching direction, recommendations or outline approaches to achieve target conservation status of Natura 2000 sites in England, to complement work already underway on individual sites. IPENS programme produced eleven 'Theme Plans' which recommend approaches to address significant issues which affect many Natura 2000 sites, and which would benefit from a strategic, rather than site-by-site approach. The Theme plans were:

- Atmospheric nitrogen
- Climate change
- Diffuse water pollution
- Grazing
- Habitat fragmentation
- Hydrological functioning
- Inappropriate coastal management
- Invasive species
- Lake restoration
- Public access and disturbance
- River restoration

IPENS has additionally developed a Site Improvement Plan (SIP) covering each Natura 2000 site. The SIP is a single, short reference document that covers the whole site(s), complementing any existing plan(s) for the site. The SIPs outline the priority issues affecting the condition of the site; identify the actions required to

address them and who is responsible for taking them forward and highlight potential delivery mechanisms and funding sources to action them (Natural England, 2015a).

Access to sufficient quantities of funding is cited as one of the most significant limitations to the implementation of the IPENS programme. Cost to address all the issues raised in IPENS is estimated at approx. £1.8 billion. As a method of incorporating offsite enhancements within a development, developers could act as a funding source to help implement the IPENS plans. The case study below provides an example of an IPENS SIP being incorporated into a develop.

*IPENS Case study: Barnack Hills and Holes SAC – planning development*

A planning application was submitted to Peterborough City Council for a housing development close to Barnack Hills and Holes SAC, an important orchid site. Natural England considered that the resulting recreational pressure was likely to have an adverse effect on the conservation interest of the SAC which would not be sufficiently offset by the provision of green infrastructure within the development. In discussions with the developer about further mitigation the SIP for Barnack Hills and Holes SAC was referred to, to get ideas of potential actions and costings. The developer agreed to fund a series of SIP measures through a section 106 agreement. Detailed plans were prepared, starting with the design of on-site green infrastructure which includes habitat creation to replicate the landscape and habitats of the Barnack Hills and Holes SAC (Natural England, 2018). In the coastal management IPENS several features were identified as 'at risk'. These could form the basis for offsite enhancement measures for coastal development (Natural England, 2015). Habitats and species highlighted are presented in Table 12.

Table 12. 'At risk' features highlighted in the coastal management IPENS

Habitats	Birds	Other species
Eelgrass	Shingle nesting birds due to flooding	Upper saltmarsh species
Freshwater habitats behind coastal defences	Little & sandwich terns & ringed plover	Starlet sea anemone
Tidal/saline lagoons/brackish habitats in general	Saltmarsh roosting/breeding birds (e.g. grey plover & dunlin)	Fishers estuarine moth
Mediterranean and thermo-Atlantic saltmarsh scrub ( <i>Suaeda vera</i> )	Overwintering waders (esp. sp. not using adjacent freshwater/agricultural habitats)	Specialist invertebrates (saline & brackish)
Freshwater marshes	Breeding Annex 1 birds (e.g. terns, avocets etc.)	Petalwort on dune slacks
Shingle habitats (perennial and annual)	Overwintering wildfowl	Shore dock in dunes and on cliffs
<i>Spartina maritima</i> swards	Waders, gulls & terns	<i>Spartina maritima</i>
Atlantic salt meadow		<i>Vertigo angustior</i>
Mudflat		Saltmarsh flora
Saline lagoons		
Saltmarshes		
Yellow dunes		
Sandy beaches		
Cliff & cliff-top habitats		
Heathland		



### 11.5.3 The Aggregates Levy Sustainability Fund (ALSF)

The Aggregates Levy is a tax on sales of primary aggregate (£2 per tonne). It covers sand, gravel and rock that has been dug from the ground, dredged from the sea or imported. It was introduced to better reflect the environmental costs of primary aggregates, and encourage the use of alternative, secondary and recycled construction materials. A proportion of the revenue raised by the levy was allocated to a research fund, termed the Aggregate Levy Sustainability Fund (ALSF), which ran from 2002 to 2011.

A separate Marine Aggregate Levy Sustainability Fund (MALSF) was established in 2004 to focus on specific issues relating to the marine industry. The MALSF was also funded by the levy and supported a £25m programme of marine research. The MALSF was delivered through the Marine Environment Protection Fund, administered by Cefas, and a separate heritage fund, administered by English Heritage. The key aims of the research programme were to improve the way in which the extraction of marine aggregates was planned, assessed and managed:

- To develop and use seabed mapping techniques to improve the evidence base of the nature, distribution and sensitivity of marine environmental and archaeological resources relevant to marine aggregate activities;
- To increase understanding of the effects of aggregate extraction activities, including noise, and their significance;
- To develop monitoring, mitigation and management techniques where applicable, underpinned by scientific research;
- To research and understand socio-economic issues associated with aggregate extraction activities; and
- To promote co-ordination and establishment of sustainable archives for the dissemination of research related to these aims to a wide range of stakeholders.

The MALSF programme represented significant public investment in UK marine research, which focussed on improving the way that the marine aggregate industry is planned, assessed and managed, and thereby reducing its environmental impacts. The research has resulted in changes for the industry and its operations and has delivered long term benefits. It has improved interactions between industry, regulators and scientists, increased awareness and understanding of the marine aggregate industry, helped to develop the capacity and capability of marine science, and provided learning and added value for the wider marine science community.

There is potential for the MALSF programme to fund offsite enhancement projects (BMAPA and The Crown Estate, 2013).



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