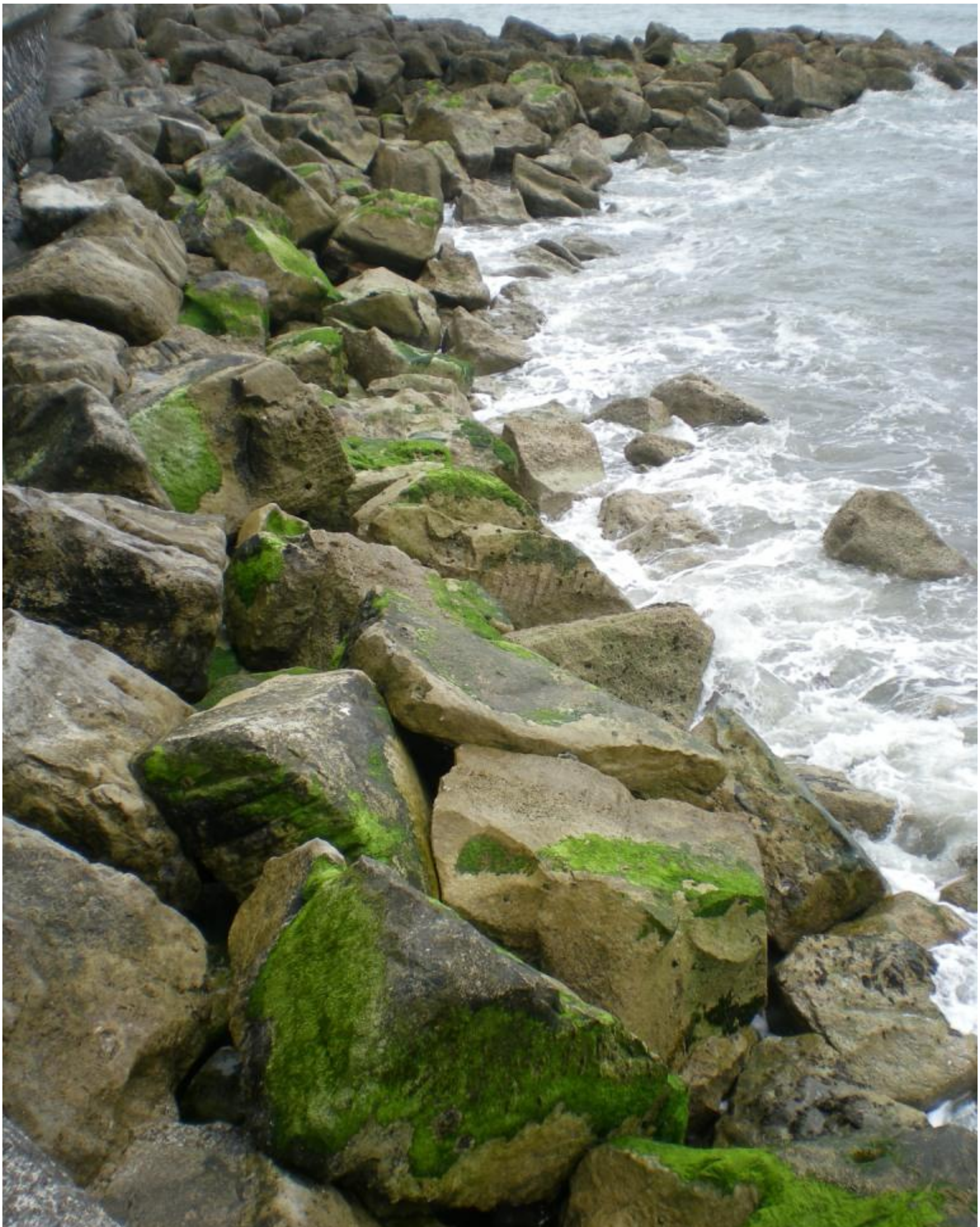
FINAL (v4.0)

Including Ecological Enhancements in the Planning, Design and Construction of Hard Coastal Structures: A process guide



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Front Page Image: Portland Limestone rubble armour at West Bay, Dorset.

EXECUTIVE SUMMARY

This guidance document discusses the idea of 'ecological enhancement' of hard coastal structures and how it can be imbedded in the design and planning process, from conception through to construction. The guidance examines the opportunities, benefits and policy drivers for incorporating ecological enhancements where hard coastal structures are being considered, examines entry points for incorporating these considerations in the planning process, and outlines which stakeholders need to be involved at each stage.

'Hard' structures in this guidance refers to those built using materials that are broadly analogous to natural intertidal rocky shore substrata (i.e. rock, stone and concrete), particularly in terms of material properties such as hardness. These can be coastal structures to minimise erosion and/or flood risk, or coastal infrastructure such as harbours and ports. Hard structures are therefore thought to have the greatest potential for ecological enhancement for species characteristic of intertidal rocky shore compared to structures built from softer or more corrosive materials such as timber or metal.

Climate change (sea level rise and increased storminess) means that hard structures will need to be built in some places if current levels of protection to people, property and businesses are to be maintained. The transformation of coastal areas for economic reasons (including for port and harbour activities, and for tourism) also means that artificial structures will continue to be built along our shorelines. This is met with ecological concerns, because artificial structures do not typically provide the same habitat types, or support the same diversity of plants and animals as natural rocky shores. They may, however, provide a greater range of habitats than structures for which ecological enhancement is not considered.

As a result, there is strong legislative pressure to minimise the environmental impacts of structures where they are built and, increasingly, to enhance for ecology wherever possible. There is, however, virtually no existing guidance on how ecological enhancements can be incorporated in coastal planning, or the kinds of enhancement options that have been tested and implemented around the world. This guidance consolidates existing information on ecological enhancement of hard coastal structures, and demonstrates how ecological enhancement can both support, and be a requirement of, the planning process.

While case studies and examples are used throughout, the guidance does not aim to provide detailed designs for specific enhancement options; the limited amount of existing research means that this must be considered on a case-by-case basis. Instead, the guidance provides a background on the principals of ecological enhancement in the intertidal zone, illustrated with examples from on-going research and operational trials. Policy and legislative tools supporting the delivery of ecological enhancements are also discussed. How ecological enhancement can be embedded at each of the key planning stages (pre-planning, planning, detailed design and tendering, construction, and post-construction stages) is outlined, along with some practical suggestions based on previous experience. Importantly, the guidance considers the business case for including ecological enhancements in coastal planning.

A QUICK REFERENCE GUIDE – Where to find key information

CONTENTS

1. INTRODUCTION

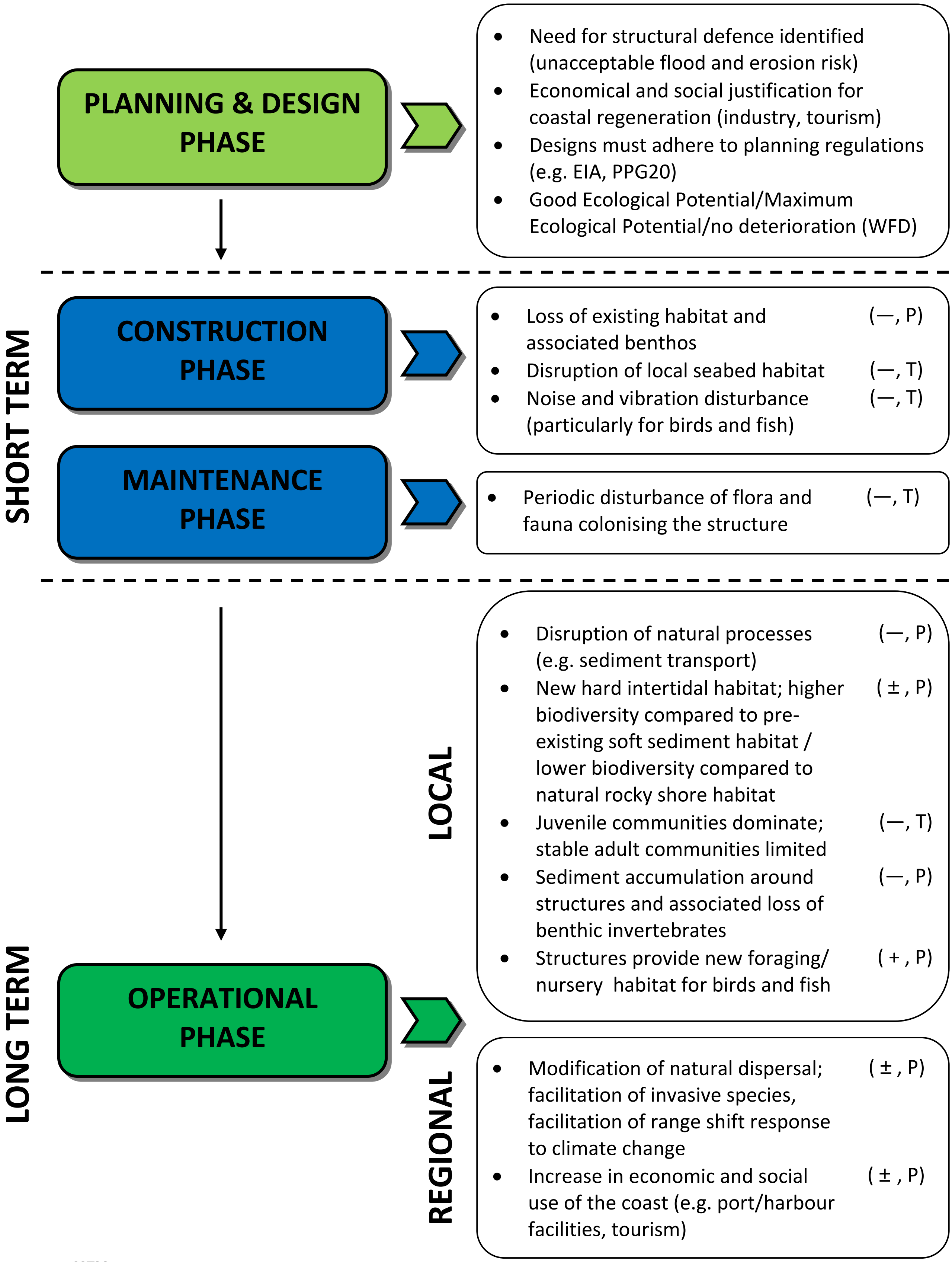
1.1. Coastal areas are valued for their environmental and economic importance. They provide many functions including protection from storms and flooding, and have landscape and aesthetic value.

"In the majority of cases, hard coastal structures are poor ecological surrogates for natural rocky shores."

1.2. Predicted sea level rise and an increase in the intensity, severity and frequency of storms, will increase the risk of flooding and erosion to people, homes and businesses, which must be appropriately managed. Managing coastal flooding and erosion risk is a multidisciplinary challenge for many groups of people including engineers, biologists, economists and politicians. Physical pressures on the coastline, the fragile nature of its habitats, and the wide range of stakeholders interested in the coast make management especially challenging.

Concrete slipway, Cape Cornwall

1.3. Building hard structures is essential in some locations for flood protection and erosion control at the coast. Structures such as walls, jetties and pontoons are also needed for valuable port and harbour activities. These structures and their associated maintenance activities can have ecological impacts, both positive and negative, and temporary and prolonged (**Figure 1**).



KEY:
Direction of impact: negative (—), positive (+), both negative and positive (±)
Persistence of impact: temporary (T), prolonged (P)

Figure 1: Environmental considerations during the planning and design, construction, maintenance and operational phases of coastal structures (developed from OSPAR 2009).

1.4. In many cases, hard structures are poor ecological surrogates for natural rocky shores[1-6], often supporting few dominant, opportunistic species such as ephemeral green algae. In addition to changing the type of substratum available for colonisation (see **Section 2**), structures also influence the surrounding environment by altering the wave climate and modifying sedimentation. These broader ecological considerations are beyond the scope of this report, but need to be considered in the ecological assessments undertaken as part of any new scheme and in replacement of existing structures.

An unenhanced concrete wall, Appledore, Devon

1.5. Importantly, the need to build new hard structures—and upgrade existing ones—to maintain current levels of protection in the face of climate change, and for economic growth[7-10] means that future alteration and disturbance of the coast will be unavoidable[11-13].

"A particular challenge is integrating the idea of '***ecological enhancement***' in the design and planning process, from conception through to construction"

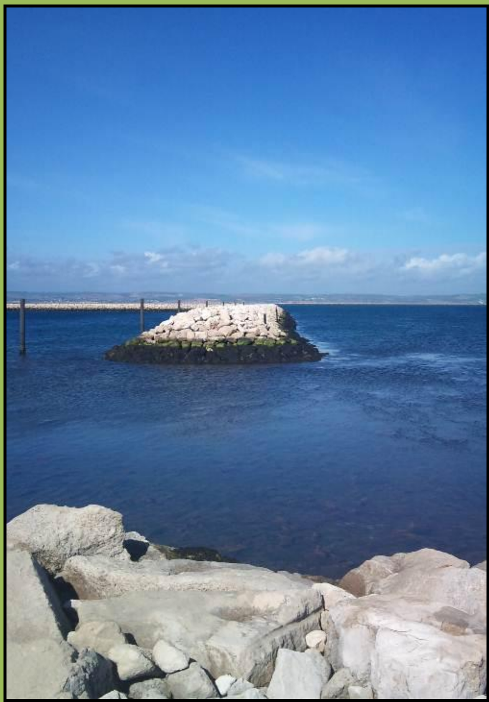
1.6. Environmental impacts must be considered during planning, design, construction, maintenance and operation of coastal structures, and avoided wherever possible[14-15]. This can be difficult because construction will always involve some disturbance of habitats and changes in the physical characteristics of the environment[16]. Designing and testing ways to improve the ecological value of structures where they have to be built is therefore a research priority[1]. A particular challenge is integrating the idea of '***ecological enhancement***' in the design and planning process, from conception through to construction.

1.7. There is an increasing amount of research being done to understand the impacts of structures on animals and plants[2-5] as well as the wider natural environment. How the design of structures might be manipulated for ecological gain is also being studied[6, 17-19]. This work is summarised in Section 2. Typically, coastal structures are designed with a particular function in mind, whether for flood defence or for access to the sea for example. Designing structures that are 'multi-functional' – so that they are of value for both industry, society and ecology, as well as fulfilling their primary function – is less common (see **Box 1**)[20].

1.8. Ecological enhancements have not generally been considered in engineering designs due to a lack of guidance for coastal managers and engineers. This is partly because this is a relatively new area of research. Up-to-date guidance is needed on the evidence and drivers (both science and policy) that support enhancement, the kinds of simple enhancement designs that are currently being tested globally, and how enhancements can get approved as part of coastal development works and help meet planning requirements.

BOX 1: 'Multi-functional' coastal structures

- Structures are built to do a particular job, their 'primary function'. This might be flood protection and erosion control, or to allow industrial and commercial activities to happen. Structures can also provide other, additional functions for people and the environment including new habitat, and offering amenity and educational value.
- A good example of ecologically multi-functional structures is near-shore rock rubble breakwaters. These are primarily built to reduce wave energy and retain beach sediment, but can also function as artificial reefs that support fish and economically valuable species like lobsters. These artificial habitats can also provide rock pooling opportunities, or even be used to improve surfing conditions to support local tourism[42].



- Ecological enhancement is therefore one important aspect of achieving ecologically multifunctional coastal structures. Alongside the primary function of a structure, these additional functions can be considered during the planning and design process to maximise the social, economic and/or environmental value of the structure.

1.1. This Document

1.9. This document gives an overview of current understanding of coastal structures as habitats, and the scientific basis and policy drivers underpinning their enhancement (Section 2). Examples of the kinds of enhancements being tested are given, but the guidance aims to provide a quick guide to enhancement and is not a 'recipe book' of enhancement options; in most cases enhancements need to be designed on a case-by-case basis. Instead, this guidance gives a step-by-step guide for including ecological enhancement in the planning and design of coastal developments more broadly, from identifying an opportunity to post-build monitoring (Sections 3 and 4).

"Alongside ecological gains, facilitating colonisation of structures offers other benefits, including aesthetic value and a means of gaining public support and meeting planning conditions."

1.10. The guidance is intended for use within the Environment Agency (EA), maritime District Councils, partner government organisations (e.g. Natural England or Countryside Council for Wales) and other interested parties (e.g. Local Authority planners, the Marine Management Organisation and developers). Within the EA, the guidance will be cascaded to teams at head office, in regions and areas, including staff involved in capital schemes and implementation of the Water Framework Directive (WFD), Strategic Flood Risk Planners, Regional Habitat Creation Coordinators and asset managers, engineers and Planning Liaison officers. The guidance will also be of interest to individuals and organisations involved coastal development works, including contractors, environmental consultants and coastal landowners.


Lyme Regis, Photo: A. Hallett

1.11. The guidance is divided into four main sections:

- **Section 1: Introduction** (this section)

  Provides an introduction to the requirement and purpose of the guidance and the intended audience.

- **Section 2: Current Knowledge State**

  Provides a brief review of existing guidance, ecological enhancement designs currently being tested around the world, and policy drivers which support the delivery of ecological enhancements.

- **Section 3: An Overview of Including Ecological Enhancements in the Planning, Design and Build Process**

  Puts ecological enhancements into the planning context and outlines where it is possible to consider enhancement in each stage of the planning process.

- **Section 4: Guidance on Including Ecological Enhancements in the Planning, Design and Build Process**

  Step-by-step guidance on where and how enhancements may be incorporated in pre-planning/feasibility, planning and post-planning stages of developments.

8-Year old Harbour wall, Ilfracombe, Devon

1.2. What is ecological enhancement?

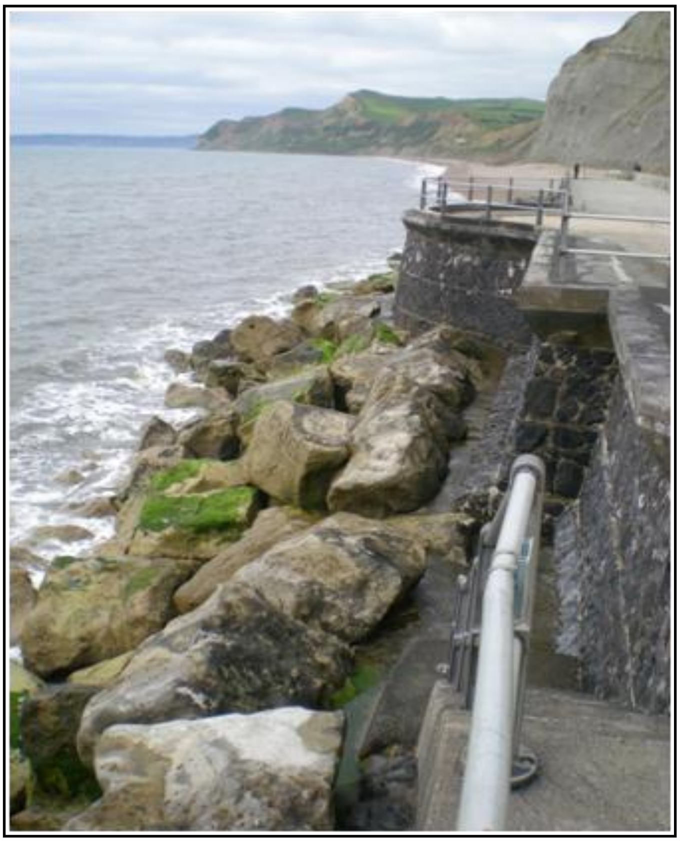
1.12. Ecological enhancement does not seek to achieve complete re-creation of natural conditions[21] but instead aims to improve the ecological 'quality' of a structure already being built for other purposes[22].

1.13. Enhancement need not always be associated with a particular development activity or past impact (unlike offset mechanisms for example)[23]. However, typically enhancement is undertaken to achieve a measureable conservation outcome where structures have to be built, and where soft alternatives are not appropriate (see Section 2.3). Enhancements may also be built in to new build or remedial works to compensate for any negative impacts of structures built elsewhere. Enhancements can also be built into part, rather than all of a new structure, to create appropriate niche habitats within coastal developments.

The historic Old Quay at Newlyn, Cornwall.

1.14. Alongside ecological gains, facilitating colonisation of structures offers social benefits, including educational and aesthetic value, and a means of gaining public support and meeting planning conditions[24]. Some of the species that grow on structures may also provide engineering and heritage value by reducing potentially deteriorative weathering processes[25-26]. The plants and animals that grow on structures offer a range of ecosystem services including the provision of foodstuffs (e.g. mussels, lobsters), environmental regulation (e.g. wave dissipation), cultural enhancement (e.g. aesthetics) and the creation of habitat for other species (e.g. sea horses)[27].

1.15. These are many ways structures can be enhanced for ecology. This includes maximising the physical complexity of the structure, or designing bespoke ecological niche enhancements for specific species. In this guidance '**general ecological enhancement**' is used to describe measures aimed at providing overall benefits for ecology. '**Specific ecological enhancement**' is used for measures targeting specific species or habitat niches.



A mix of material types at West Bay, Dorset.

1.16. **General ecological enhancement** considers the environmental conditions offered by a structure when built, but does not necessarily involve direct modification of the design specifically for ecological gain. General enhancement might include arranging boulders in rock rubble groynes to maximise void space[28], selecting construction materials with rougher surfaces, using a mix of materials in the design, or positioning a structure lower in the tidal frame[6]. General ecological enhancement offers the greatest opportunities when the drivers and resources for specific enhancement (see below) are limited; this might include the absence of a planning requirement or limited budget, and technical, knowledge and time constraints.

1.17. **Specific ecological enhancement** can be undertaken as part of the original design, such as building in rock pools in vertical walls[17], or retrofitting niches after construction[19] (**Figure 2**). As well as being more technically challenging, specific ecological enhancement requires understanding of the factors influencing local ecology and, if targeting particular species', the specific habitat requirements of the target organism at all life-stages[19].

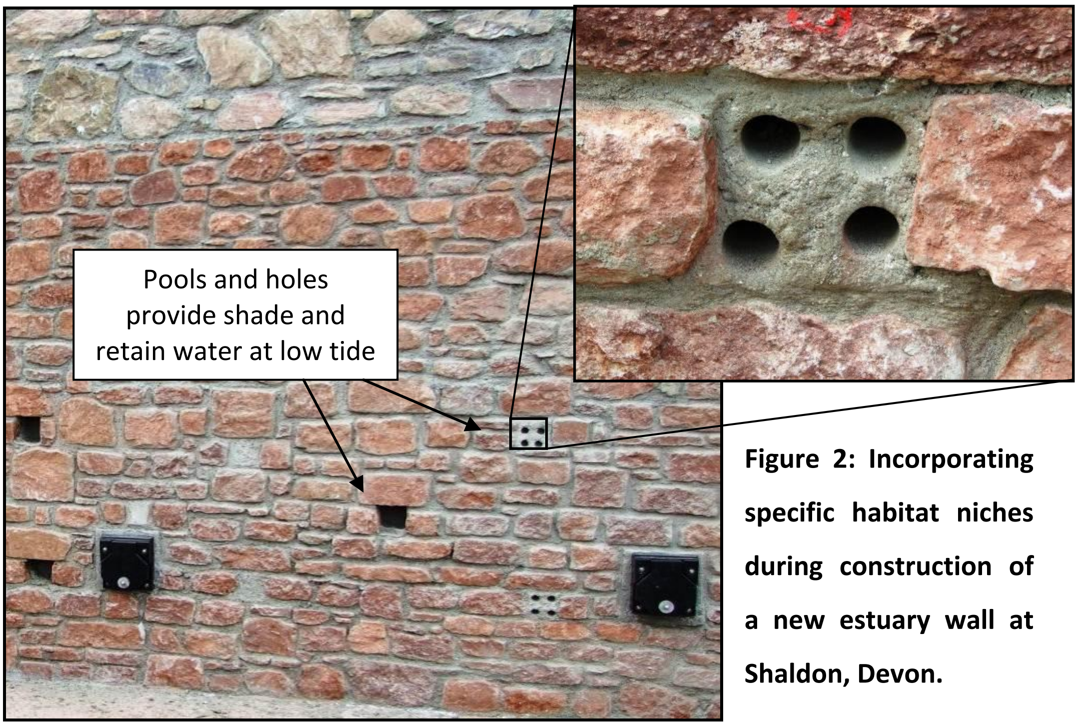


Figure 2: Incorporating specific habitat niches during construction of a new estuary wall at Shaldon, Devon.

1.18. Ecological benefits can also occur unintentionally. A hard structure may provide new surfaces for colonisation in severely degraded environments regardless of its design [29]. Placing rock rubble in font of a vertical seawall for wave dissipation will increase the range of habitat niches available to intertidal organisms[29]. Natural weathering and erosion of limestone rock over long timescales can also create beneficial habitat complexity[30]. These kinds of ecological gains may not be specifically planned for, but recognising where they occur and monitoring how they function is important for informing the design of other 'general' and 'specific' enhancements. More examples of general and specific enhancement are given in Section 2 of this guidance.

1.19. On Plymouth Breakwater, 100 ton concrete wave breaker blocks have been placed on the seaward side to dissipate wave energy. These blocks have depressions used to transport and lift the blocks into place. Although purely an artefact of construction, these features retain water at low tide and create rockpool habitat, **Figure 3**a-b[31]. Natural weathering of the breakwater over time has also enhanced surface texture leading to positive ecological outcomes, **Figure 3**c-d[6, 30].

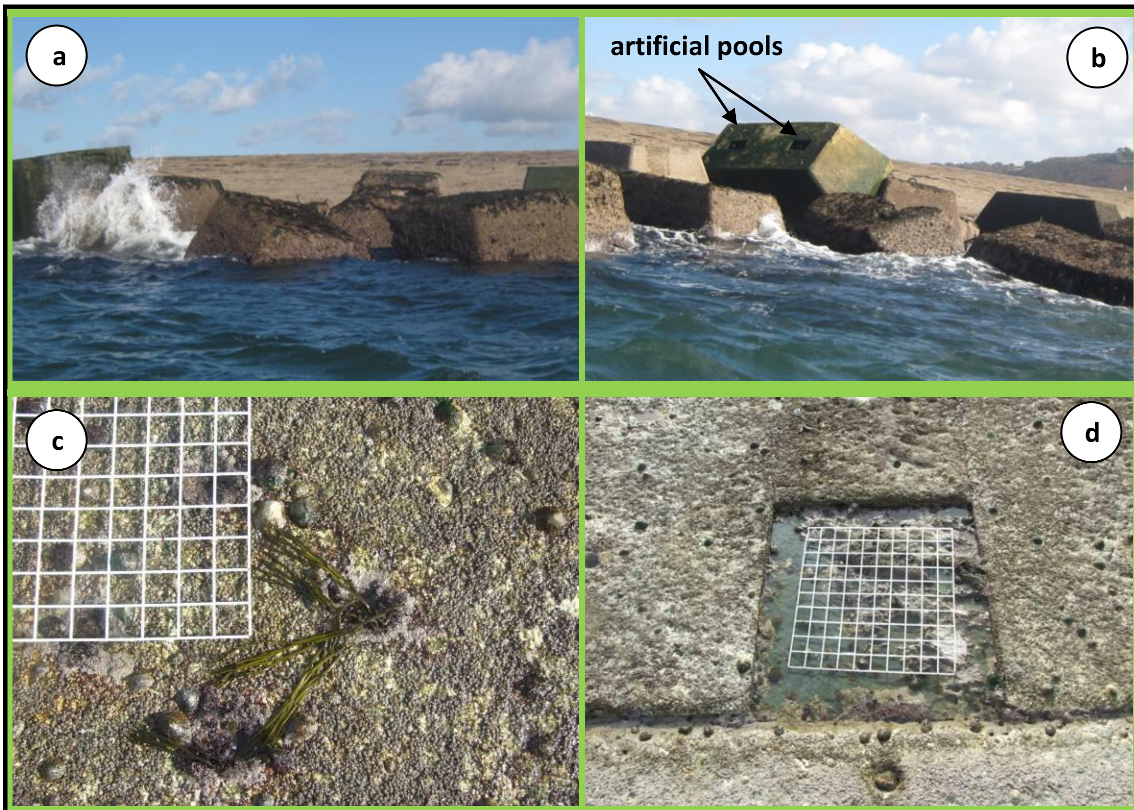


Figure 3: The primary function of concrete breakers on Plymouth Breakwater is wave dissipation (a); engineering artefacts (depressions/holes for used for positioning) also function as habitats (b and c); weathering of limestone can also create valuable water retaining microhabitats over decades and centuries (d). (Photos: J. Jackson, M. Coombes).

1.20. In some instances, it may neither be advisable nor desirable to undertake ecological enhancements, although enhancement should always be considered. This might include areas where there is a higher than normal risk of invasive species, such as container ports[32]. Non-native, invasive species can have substantial ecological impacts, and may displace native species or change environmental conditions. Where invasive species are considered a potential threat, particular materials, surface finishes and treatments (e.g. very smooth, hard materials and antifouling coatings) could be used to limit colonisation[30, 33-34]. In such instances, alternative types of enhancement should be considered, or compensatory habitat created elsewhere[35].

1.21. The potential opportunities and feasibility of habitat enhancement will be site specific, depending on several factors including the supply of organisms from the local species pool, the tide level at which the structure is to be placed, and the local wave and sediment regime.

2. CURRENT KNOWLEDGE

2.1. Factors influencing intertidal ecology on structures

2.1. The ecology associated with artificial structures is often compared to natural rocky shores as they are considered the nearest natural equivalents[11]. Rocky shore research is therefore important to help identify which features of structures could be manipulated for ecological gain.

Diverse rockpool community on a natural rocky shore.

2.2. The main factor influencing ecological communities on natural shores and structures is position within the tidal frame. In the intertidal zone species experience periods that are marine and periods that are essentially terrestrial. This places limits on what species can survive at different tidal heights depending on their tolerance to heat and desiccation, and creates a characteristic ***zonation*** of species[36-37].

2.3. Waves also influence ecology. Waves can cause scour, circulate water, and disturb or deposit sediment which can directly disturb animals and plants or limit feeding[38]. Wave energy varies around the coast depending on local and regional weather (i.e. wind) conditions, wave fetch (the distance over the sea the wind has travelled), and the slope of the shore or structure[38]. Physical conditions experienced by organisms can therefore be very different on wave-exposed and wave-sheltered parts of structures, so different species will be able to colonise particular areas while others may be excluded[6].

2.4. Rocky habitats and structures made of natural rock or concrete boulders and blocks provide biological richness compared to flat, 'smooth' bedrock and cliff habitats due to the range of ***microhabitats*** such as overhangs, crevices, caves, pools and damp areas [37-38]. Rock type and texture also influence water drainage and ponding, which can be important for micro-climatic conditions. These features provide ***refuge*** for animals and plants from waves, predation, heat and desiccation stress. How physically complex a surface is, termed '***habitat complexity***', has a strong influence on ecology[37-38]. Complex habitats (i.e. rough) offer more microhabitats than simple (i.e. flat and smooth) surfaces. This means that the number of different species that can colonise and survive on complex surfaces is usually higher[3, 20].

2.5. On artificial structures, the presence of refuge habitat (crevices, pools, grooves etc.) will increase the number of species that grow on them (**Figure 4**)[17]. Importantly, different species, and different life-stages of species (e.g. larvae and adults), have specific habitat preferences. Habitat complexity at different spatial scales (whether a millimetre scale pit or a centimetre scale hole) is therefore important for healthy, diverse and productive ecological communities[17,20].

Figure 4:

Rough and physically complex materials (e.g. quarried rock) can provide habitat niches and refuge for a range of animals and plants when used in coastal engineering.

2.6. Understanding of these different factors is helping to identify design features of artificial structures that currently limit ecology, and how they can be modified to improve conditions for colonising organisms.

2.2. Existing guidance and ecological enhancement trials

2.7. Enhancement options are increasingly being considered in engineering design (**Figure 5**). The Manual on the Use of Rock in Hydraulic Engineering[39] gives some broad consideration such as position of the structure within the tidal frame, alongside specific suggestions like incorporating crevices. In contrast, the revised Manual on the Use of Concrete in Maritime Engineering[40] gives no specific consideration of ecological enhancement, but does refer to ongoing research on this topic.

Figure 5:

There is some, but limited guidance on considering ecological enhancements in the planning and design of coastal structures.

2.8. The EU DELOS Project (www.delos.unibo.it) examined existing coastal defence structures in Europe and produced the most comprehensive guidance for environmental considerations in engineering design to date[24]. DELOS highlights the importance of habitat heterogeneity (habitat complexity), the ability of water to pond at low tide, and the influence of time (i.e. age) on the types of ecological communities found on structures[6] (**Box 2**).

"There is 'very high' potential for influencing ecological communities developing on artificial structures by simple modifications to engineering design."

BOX 2: Environmental Design of Low Crested Structures (DELOS)

- The DELOS project showed how different design features of hard coastal structures influence ecology, including:
    - the position of the structure within the tidal frame;
    - the spatial arrangement and distance between structures;
    - distance from the shore;
    - length of the structure;
    - proportion of submerged verses emerged elements;
    - the type of material used;
    - the porosity of the structure (e.g. gaps between boulders);
    - frequency of maintenance works.

  These factors should be considered when planning new structures to minimise impact on existing habitats, and maximise the ecological potential of the new structure.

A rock rubble groyne, Douglas, Isle of Man (Photo: R. Thompson)

- The DELOS project concluded that it is possible to modify structures to enhance ecology within the limits set by the primary engineering function. Enhancements can therefore be used to maximise secondary management end points (e.g. **Box 1**), including:
    - The provision of habitats to support living resources for exploitation of food (such as shellfish and fish);
    - The provision of habitats recreational (e.g. angling, snorkelling) or educational (e.g. rock pooling or ornithology) activities;
    - The provision of habitats to support endangered or rare species, and rocky substrate assemblages for conservation or mitigation.

2.9. The '**Estuary Edges**' project developed guidance on enhancing and making positive contributions to estuarine environments, involving a team of ecologists and engineers. The guidance outlines opportunities and constraints for supporting wildlife, improving public access and educating people about the importance of estuaries (**Box 3**).

BOX 3: Estuary Edges

The 'Estuary Edges' project explored four categories of designs for estuarine environments and the ecological gains that could be achieved:

Bioengineered designs	• Plants are used for long-term protection from erosion, and aim to mimic natural systems, but may be inappropriate in all situations. • The ecological value of such designs is closest to that of a natural tidal bank.
Biotechnically engineered designs	• Plants contribute significantly to the design but harder engineering elements are also used for stability. • The ecological value of such designs can approach that of a natural bank.
Structurally engineered designs	• These designs are mainly artificial, with ecological elements added on. • The ecological value of such designs varies widely, but can be high.
Hard engineering	• These designs are used when there is too much water energy for ecology, other than seaweed and exposure-tolerant invertebrates. • The ecological value of such designs is generally negligible.

For more details and example designs see: www.environment-agency.gov.uk/business/sectors/100745.aspx

2.10. Given the limited number of operational trials and scientific studies globally, it is not currently possible to provide specific design advice for ecological enhancements. This guidance does not aim to specify which enhancements to adopt at a given location, but a summary of known examples trialling enhancements for hard coastal structures is given in **Appendix B**. The examples illustrate the kinds of modifications that may be considered during the planning and design process. Some selected examples are discussed below.

Figure 7: Artificial pools in a vertical sandstone wall, Sydney Harbour, Australia (Photo: G. Chapman, EICC, University of Sydney).

Figure 6: Using artifical niches (holes, 24 x 10 mm) to enahance limpet stocks on a basalt seawall, São Roque, Portugal. (Photo: G. Martins).

2.11. **Including habitat niches in structures:** Increasing surface heterogeneity and incorporating niches in structures can improve conditions for target organisms, or increase general ecological potential. Examples include designing in pools to retain water at low tide, such as those used in Sydney Harbour, Australia (**Figure 7**)[17] and the Shaldon and Ringmore Tidal Defence Scheme, UK (**Figure 2** above and **Appendix B**), or by making modifications post-construction. In Portugal, microhabitats (holes) added to a vertical seawall enhanced stocks of an over exploited limpet species, and also influenced their spatial distribution (**Figure 6**)[19]. In Seattle, Washington, USA, a pilot study has been commissioned by the City of Seattle where the University of Washington designed a series of pre-cast test panels with different structural modifications which are currently being monitored (see **Appendix B**).

2.12. **Manipulating fine-scale surface texture:** Rough materials are generally better than smooth for ecology. Rougher materials may be selected for construction (e.g. choosing the roughest rocks from a quarry for rubble structures or for cladding walls etc.) or, alternatively, materials can be textured artificially. There is increasing evidence to suggest that artificial texturing can influence the rate of colonisation when placed in the sea. For example, studies testing texturing of marine concrete in Cornwall, UK (**Figure 8**), have shown that a brushed surface texture (created when the concrete is curing) can significantly increase barnacle colonisation rates[18, 30].

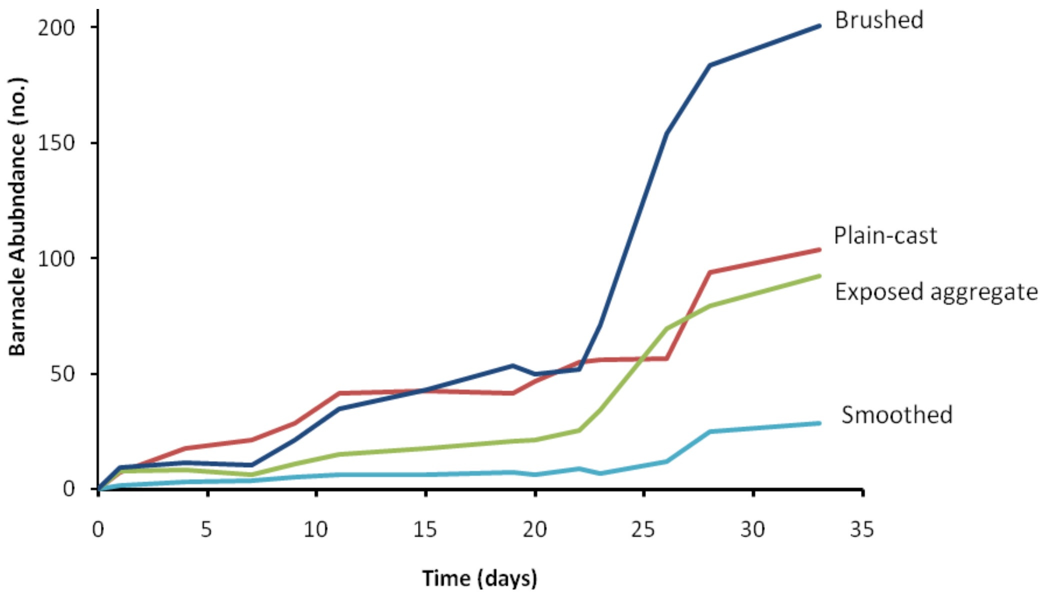


Figure 8: Manipulating barnacle colonisation using fine-scale texturing of marine concrete[30].

2.13. Collaborative projects with contractors and materials suppliers are now needed to examine the practical options and economic implications of incorporating texture manipulation in structure designs. There may be particular opportunities here with respect to pre-cast concrete structures. For example, a PhD project funded by the EU European Social Fund and Combined Universities in Cornwall, with Ladds Concrete Limited as the primary business partner, is commencing in October 2011. It will investigate the potential for designing ecological enhancements into pre-cast concrete designs using texture, as well as the aesthetic and scientific outcomes of this kind of manipulation.

2.3. Cost of enhancements relative to total project costs

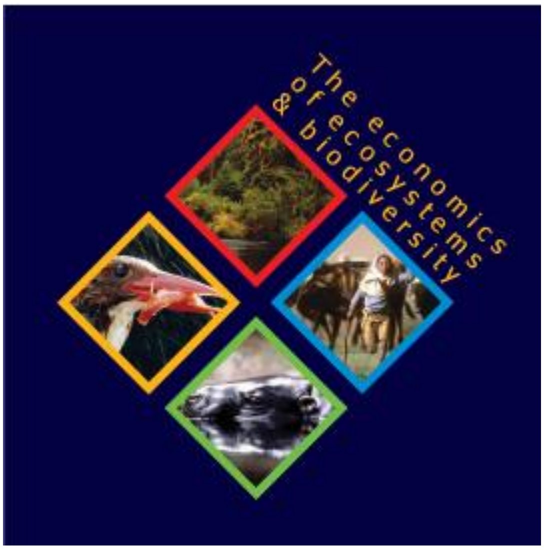
2.14. Evaluating the additional cost of including ecological enhancements as part of flood risk management projects is of central importance if they are to be justified. This is especially the case where there are no policy or legislative drivers requiring enhancement. This can be done simply as the percentage of the enhancement cost relative to total project cost. Whilst a more in-depth cost-benefit analysis is preferable, this is not currently possible for the very limited number of operational trials to date. Such an evaluation is given below for two operational enhancement trials, the EA funded scheme at Shaldon, Devon and the seawalls trial in Seattle, Washington (see **Appendix B** for further details of these schemes).

Testing habitat enhancements in Seattle, Washington (Photo: C. Levy).

2.15. For the Shaldon and Ringmore Tidal Defence Scheme, the total project cost was £6.5m, and required ecological enhancements to be incorporated in the final design. An experimental trial was designed to test various enhancements (see case study in **Appendix B**) following efforts from in-house EA staff, contractors responsible for overseeing the build phase (Atkins), external EIA consultants (Treweek Environmental Consultants), masons and specialist academic researchers (Universities of Exeter and Plymouth). The estimated cost of creating the trial was £20K; this represents 0.3% of the total scheme cost. Half of the enhancement costs were provided by the EA, and the Universities were able to provide the additional funding as an outcome of a research project jointly funded by the EA and Great Western Research (see: www.exeter.ac.uk/coastaldefencesbiodiversity, accessed June 2011). The University of Plymouth is undertaking further ecological monitoring at the site as part of a longer-term, EU-funded project.

2.16. The 'Seattle Seawalls' project (sites.google.com/a/uw.edu/seattle-seawall-project/design, accessed June 2011) was designed as pilot study of ecological enhancement options to support a planning application by the City of Seattle for a replacement seawall (see **Appendix B**). The pilot study was used to test designs for the final project, meet conservation targets, help win public support, and aid securing planning approval and additional funding. The total cost of the pilot study represented only 0.2% of the total project budget (Noble, pers. comm. 2010).

2.17. These examples suggest that enhancing can be affordable. There are also additional benefits that are difficult to price. In both of the cases above, for example, the ecological enhancements helped secure planning approval where there were predicted ecological impacts and limited options for other mitigations.



www.teebweb.org

2.18. Where enhancement is trialled or implemented operationally, additional funding is needed to enable detailed cost-benefit analysis alongside long-term monitoring of ecological gains. This will help further demonstrate the value (financially) of ecological enhancement. **The Economics of Ecosystems and Biodiversity** study (TEEB), for example, emphasises the concept of ecosystem valuation as an aid to decision-making. Companies must anticipate that ecosystem valuation will become more consistently incorporated into public policies, regulations, and political decisions.

2.19. The objectives of the UN Convention on Biological Diversity (CBD, 2010) put strong demands on government authorities and business to measure and report their actions to conserve, and sustainably use and share the benefits of ecosystems and biodiversity. In the UK, the coalition government is pursuing an agenda that may see biodiversity offsetting and potentially payments of ecosystem services mainstreamed into local policy requirements. If implemented this should support the financial incentives for incorporating ecological enhancements in hard coastal structures.

2.4. Legislation, Policy and Planning Tools Supporting Enhancement

2.20. There are many pieces of legislation and policy instruments that support or require ecological enhancement. National and local level initiatives, commitments, good practice and technical standards also support the design and testing of enhancement options. These are summarised below and listed in **Appendix C**.

"Considering ecological enhancements in planning and design offers opportunities to meet these statutory requirements."

European Law

2.21. In Europe, the ***Water Framework Directive*** (WFD, 2000/60/EC) outlines conservation requirements for all waterbodies including ports, harbours and defended coastlines. It requires that waterbodies achieve ***good ecological status***, and that development activities do not lead to deterioration or prevent the required status being achieved.

2.22. Where waterbodies have been significantly altered through human activities (termed 'heavily modified') the required status is ***good ecological potential***; this includes some coastlines with existing hard defence structures. There is also a requirement to prevent deterioration where possible. Considering mitigation through the planning process offers the opportunity to meet these requirements where new structures where they have to be built, and provides a tool for developers to gain licensing and development consent (**Box 4**).

BOX 4: WFD Mitigation Measures Manual

To help meet the requirements of the WFD, the EA has produced guidance on '***mitigation measures***' that can help achieve good ecological status or good ecological potential. Measures most relevant to hard coastal structures include modifying or enhancing the structure for ecology (i.e. ecological enhancement), and managing and restoring the intertidal zone. The manual is available online at: http://evidence.environment-agency.gov.uk/FCERM/en/SC060065.aspx

2.23. The European ***Habitats Directive*** (1992/43/EC) and ***Birds Directive*** (1979/409/EC) also support the protection, enhancement and restoration of biodiversity[14,41]. Where plans and projects are expected to impact 'Natura 2000' sites and (in the UK) Ramsar sites, an ***Appropriate Assessment*** (AA) is required to identify avoidance and mitigation measures. If this cannot be achieved, a complex set of steps must be followed, including proving absence of alternatives, demonstrating overriding reasons of public interest, and securing compensatory habitat if approval is to be gained[42]. Including enhancement measures to support policy requirements throughout the planning and design phases of new developments offers opportunities to avoid these complications.

2.24. The ***Environmental Impact Assessment*** (EIA) Directive (85/337/EEC and 97/11/EEC) and ***Strategic Environmental Assessment*** (SEA) Directive (2001/42/EC) require assessment of all environmental consequences of projects (including at the coast) before any construction commences. Alternatives must be considered, and measures to prevent or reduce adverse environmental effects must be outlined[43]. These two Directives therefore provide a key opportunity for including ecological enhancement in new coastal structures early in the planning process.

2.25. The ***Marine Strategy Framework Directive*** (2008/56/EC) also 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[44] for which general and specific ecological enhancements may be appropriate where new structures need to be built.

2.26. The UK is also committed to reducing the current rate of loss of biodiversity under the International Convention on Biological Diversity (CBD)[45]. Under the CBD COP10, biodiversity values must be incorporated into all planning processes, to address the underlying causes of biodiversity loss and to reduce the degradation of natural habitats; ecological enhancement can assist meeting these requirements.

UK Primary Legislation & Statutory Regulations

2.27. The **Marine and Coastal Access Act 2009** introduced a new framework for planning and managing activities in the marine environment to deliver the Government's commitment to clean, healthy, safe, productive and biologically diverse oceans and seas[46]. The Act will have a significant impact on the way biodiversity and the use of our seas and coast are managed, and supports the delivery of good environmental and ecological status under the Marine Strategy Framework Directive and the WFD (**Box 5**).

BOX 5: Marine and Coastal Access Act 2009

Aspects of the Act of relevance to hard coastal structures include:

- A new marine planning framework comprised of a UK **Marine Policy Statement** (MPS) and a series of **marine plans**;
- The creation of the **Marine Management Organisation** (MMO) to deliver marine planning and licensing in England. In Wales, the Welsh Government will lead marine management and regulation;
- Creation of new **Marine Conservation Zones** (MCZs) which together with European Marine Sites will form a representative network of Marine Protected Areas (MPAs).

Marine activities, including coastal defence works, must comply with marine plans (or the MPS prior to plans being developed). If structures are also within a MCZ, ecological enhancements may help meet the conservations objectives of the MCZ.

The objectives and policies of the relevant marine plan (when available) should be inspected when considering design of ecology enhancements to ensure actions are mutually supportive.

2.28. The **Natural Environment and Rural Communities Act** 2006 (NERC) imposes a duty on public bodies and Local Authorities to conserve biodiversity, which includes restoring or enhancing a population or habitat. The duty therefore extends beyond conserving existing biodiversity to include carrying out and supporting actions to restore or enhance ecology.

2.29. Under the **Countryside and Rights of Way Act** 2000 (CROW) biodiversity conservation is given a statutory basis, requiring government departments to take positive steps to further the conservation of listed species and habitats; enhancement is included under the definition of conservation adopted by the Act. Furthermore, the **Biodiversity Strategy for England** (2002) states that 'construction, planning, development and regeneration should have minimal adverse impacts on biodiversity and should enhance it where possible'.

UK Biodiversity and Planning Policy

2.30. In England, planning authorities must adhere to ***Planning Policy Statements*** (PPSs) and the former Planning Policy Guidance Notes (PPGs) if planning permissions and licences are to be obtained; these require potential impacts of planning decisions on biodiversity and geological conservation to be fully considered[24]:

- **PPS9** (Biodiversity and Geological Conservation) states that new development should be refused permission where significant environmental harm cannot be prevented, adequately mitigated, or compensated for. PPS9 also stipulates that biological and geological diversity are conserved and enhanced where possible.
- **PPG20** (Coastal Planning) and **PPS25** (Development and Flood Risk) provide additional support for including enhancements in coastal developments.
- It is also worth noting that in the near future the current PPS planning system will be incorporated into a National Planning Policy Framework.

2.31. In Wales, ***Technical Advisory Notes*** (TANs) support planning and development decisions. **TAN 5** (Nature Conservation and Planning), **TAN 14** (Coastal Planning) and **TAN 15** (Development and Flood Risk) call for consideration of ecological and environmental impacts in the planning process, including the creation and maintenance of conservation sites[47].

Good Practice and Technical Standards

2.32. The EA takes a best practice approach to the integration of environmental enhancements wherever possible. It interprets the duties under the Environment Act (1995) through internal guidance. For EIAs, for example, the EA specifies that all projects should consider opportunities for environmental enhancement for all Internal Works and Activities[48].

2.33. The word ‘enhance’, and synonyms for it, is common in the governments ‘Guide to Good Practice accompanying PPS9, and the ‘Guidance for Local Authorities on Implementing the Biodiversity Duty’ also states that opportunities for biodiversity enhancement should be actively sought[49].

2.34. Other drivers for including ecological enhancements include raising public awareness and acceptance of new developments, improving success with planning applications and increasing chances of securing additional funding. In the Seattle Seawalls project for example (see **Appendix B** for details), a pilot study of enhancement options was used to support application by the City of Seattle for a new seawall.


Porthcawl, Wales

3. INCLUDING ECOLOGICAL ENHANCEMENTS IN PLANNING: AN OVERVIEW

3.1. Proposers of new hard coastal structures must adhere to planning guidelines and other applicable legislation (Section 2 above). The planning process involves a number of sequential stages that provide a useful framework within which ecological enhancements can be considered, as shown in **Figure 9**.

> "The planning process involves a number of sequential steps which provide a useful operational framework within which ecological enhancements can be considered."

3.2. Ecological enhancement may be considered at several points in the planning process for new structures, or when maintenance, repair or replacement of existing structures is needed. For example, at the pre-planning/feasibility stage of a project (Stages 1-2 in Section 4) construction materials may be decided, when scientific evidence of the influence of material type and texture on ecological outcomes can be used to inform decisions.

3.3. **Table 1** outlines high-level, general enhancement recommendations for each opportunity identified at the different planning stages. Section 4 provides a more in-depth discussion of each of these steps.

Clovelly, Devon

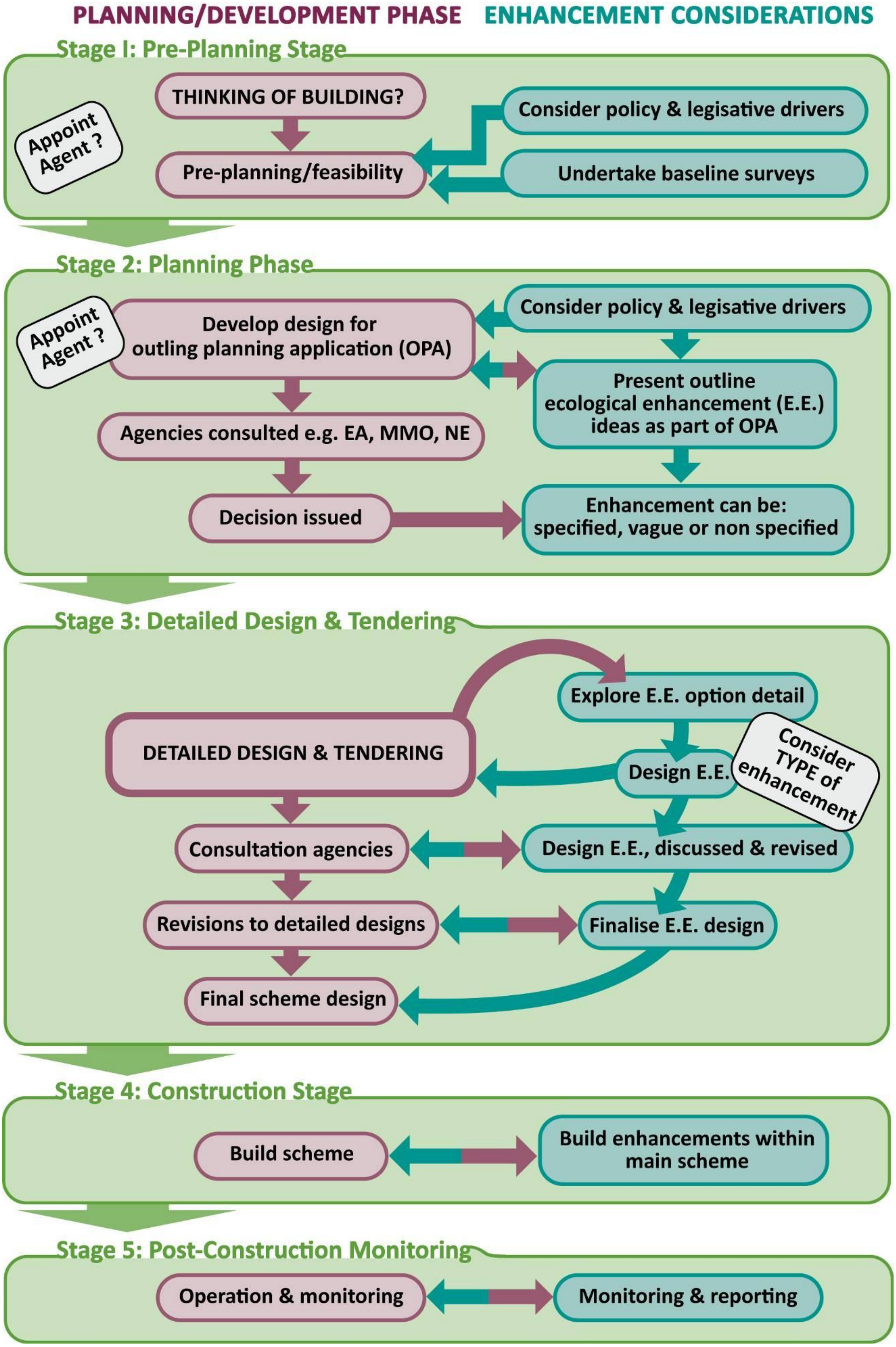


Figure 9: Stages of the planning process at which ecological enahcnement can be embedded.

Table 1: Key stages in the planning, design and build stages of coastal structures where ecological enhancement can be embedded.

PLANNING STAGE	DESCRIPTION	ENHANCEMENT OPPORTUNITY	SUGGESTED ENHANCEMENT MEASURE
STAGE 1: PRE-PLANNING FEASIBILITY	Consider ecological enhancement as part of any examination of alternatives to meet a set of objectives, and potentially pilot testing of hard structure designs. Conduct baseline ecological surveys.	First examine opportunities for meeting planning objectives through development of soft alternatives (such as managed realignment) which work with natural processes to reduce flood risk. If hard defences are required, testing specific habitat enhancements (prior to planning approval for a structure) to help secure planning support and/or additional funding.	Testing of general or specific enhancement designs, prior to implementing.
STAGE 2: OUTLINE PLANNING	The team commits to incorporation of enhancement and the location and extent of enhancement to support planning submission. Specific requirements, material choices and design specifications may be decided.	The opportunity depends on the inputs and outcomes of the planning process, including whether detailed designs were agreed at this stage of the process or not. Enhancements can be not-specified, vague and/or specific.	***Specific:*** Enhancements are required under planning, such as a specific conservation goal or requirement. ***Vague:*** Some enhancements are required as part of the planning process, the details of which are not specified. ***Not-specified:*** no explicit requirement for enhancement as part of the planning process. Non-mandatory drivers could be used.

STAGE 3: **DETAILED DESIGN AND TENDERING**	Design and build, or design phase of a scheme, followed by the build contract. This can be in terms of what a client requests of a contractor via tendering, or cascading this information to the design and build companies, and the suppliers.	Prospective designers, contractors and/or suppliers could choose to use/supply materials which promote enhancement (e.g. **Box 9**).	There is an opportunity to improve awareness of the potential for enhancement, and what role the tendering/supplying process can play in 'general' enhancement. This could help ensure enhancements are better incorporated and/or specified in tender bids.
STAGE 4: **CONSTRUCTION**	Planned enhancements should be tested where appropriate (e.g. test panels, test walls etc.). Building of the structure.	Last minute changes in the designs to accommodate construction problems on-site may limit planned enhancements, or perhaps provide further opportunities to enhance.	On-site adaption of the design may be required.
STAGE 5: **POST CONSTRUCTION & MONITORING**	Many development contracts will tie the contractor to address any defects that arise during a specific period.	Monitoring of enhancement features should be included within the contractual requirements to examine how the features are being colonised and whether they are performing as expected. This is critical to inform future schemes.	Ensure arrangements are made for monitoring and reporting on the function of the ecological enhancements adopted.

3.1. The Role of Key People in Making Enhancements Happen

3.4. In the design, planning and approval process of any coastal structure there are multiple—and potentially competing—demands that the developer, asset owner and manager need to address. Typical requirements that need to be met are outlined in **Box 6**.

BOX 6: TYPICAL REQUIREMENTS OF COASTAL STRUCTURES

- **Meeting the required specification (e.g. 100-year standard of protection) and a specific purpose (e.g. reduction of overtopping or erosion protection);**
- **Durability/design life (i.e. engineering requirements);**
- **Local environmental, aesthetics, landscape, historic considerations (e.g. 'in keeping' with the environment);**
- **Resource use (e.g. procurement and sourcing; cost vs. sustainability issues);**
- **Ecologically sound (e.g. compensation, mitigation or enhancements required);**
- **Meeting specific legislative or planning requirements (e.g. EC WFD good ecological status or maximising ecological potential, and no deterioration);**
- **Cost appropriate to the benefits provided (see Section 2.3) and within budget.**

3.5. Enhancements should be seen as an important part of planning requirements, rather than as an 'extra' which can be cut when costs have to be rationalised. The legislative, policy and good practice requirements for ecological enhancements are set out in Section 2.4. The role of key people in driving through inclusion of ecological enhancements in both design and construction cannot be underestimated.

3.6. Operational ecological enhancement is inherently multidisciplinary and involved various parties. Flood defence engineers, construction managers and strategic planners may see enhancements (or WFD mitigation) as an 'extra' burden, while other teams will be more concerned with ensuring that landscape architecture requirements are met. WFD specialists are tasked with ensuring the development is compliant, and EIA specialists and conservation staff may see enhancement as a means of meeting the requirements of legislation. All involvement of all these parties means that their different roles, training and expectations needs to be effectively managed during the planning, design and construction processes.

3.7. There is growing awareness on the value of effective science-policy and science-practice interfaces[50]. Specifically, where a plurality of disciplines and views exists there is a need for selected individuals involved in the planning and design of projects to act as '**knowledge brokers**' or interpreters[51].

3.8. Knowledge brokers are intermediaries who serve to bridge between the producers and users of knowledge. They facilitate interactions or translate the information to make it relevant for the end-user (**Box 7**). Knowledge brokers have a knack for helping people see the value of 'an enhancement' from their perspective, by having a solid understanding of the political, economic and other factors influencing a decision. For projects involving engineers, construction managers and strategic planners for example, ecological enhancement can be sold as a means of meeting legislative requirements, key performance targets or non-mandatory drivers.

BOX 7: KNOWLEDGE BROKER CASE STUDY

Knowledge brokers were key to the successful inclusion of ecological enhancements as part of the Shaldon and Ringmore Tidal Defence Scheme (see **Appendix B**), Devon. Here, a knowledgeable person (from the NEAS team) was instrumental in liaising between four core groups:

- the funders (EA);
- the contractors (Atkins/Interserve);
- the designers (academics); and
- other key players such as landscape architects.


Test wall meeting, Shaldon

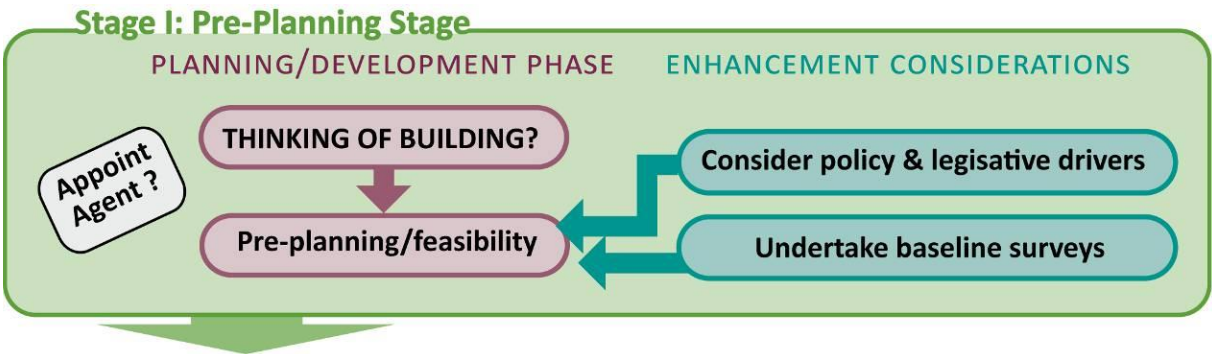
Sufficient time was also required to foster relationships and allow iterative discussions to finalise an ecological enhancement design. This ultimately allowed co-ownership of the delivery of enhancements by a knowledge broker and the core team members.

4. GUIDANCE ON INCLUDING ECOLOGICAL ENHANCEMENTS IN THE PLANNING, DESIGN AND BUILD PROCESS

4.1. This section provides detailed advice on including ecological enhancements in the main stages of planning typically involved in building structures. For each of the stages in **Figure 9**, the following will be discussed:

- What questions need to be asked to determine whether an enhancement opportunity exists and how to develop it?
- What baseline surveys are required and where?
- Who needs to be contacted? Who might be able to provide advice?
- What examples are available to draw on?

STAGE 1: PRE-PLANNING



4.2. This is the early stage where the developer, organisation or authority is thinking of building. The need to develop new or refurbish existing coastal structures may be identified for several reasons. This includes unacceptable flood risk to people and property, or the need for infrastructure for private, commercial purposes. At this stage there is scope to adapt the 'whole design' philosophy, taking account of natural processes in the design including physical positioning and geomorphic processes, and facilitating natural ecological processes via enhancements.

4.3. In Stage 1 (pre-planning) there is an opportunity to assess the value of potential enhancements. The developer will commission survey work to understand the local environment, and to gather information to support the outline planning application. A key component of this assessment needs to be evaluating baseline ecological conditions at the site where works are intended.

TIP: Use baseline ecological surveys at the proposed development to inform decisions about enhancements – consider what is there that you want to conserve, and what is not there could be encouraged.

4.4. Ecological surveys will provide evidence of enhancement potential for the proposed scheme, and baseline information on which ecological outcomes of any enhancements adopted can be assessed. The ecology of the existing habitat (pre-development) should be evaluated to identify the current community type, which will inform selection of design features that might be manipulated in the enhancement. Target species to conserve, or that may be encouraged if not currently present (e.g. UK BAP species) may be identified. Local habitats analogous to the planned structure (nearby rocky shores where conversion from shingle to rock rubble is planned for example) should also be surveyed where possible. This will be important to identify which species and community types are likely to establish on the structure, and therefore which design features will be most important for their development.

Conducting ecological surveys before and after construction to inform enhancement designs and evaluate outcomes (Photo: M. Goff).

BOX 8: BASELINE SURVEY CASE STUDY

A 'Rapid Appraisal' of the ecology, habitats and geomorphology of a series of structures at Portland Port was recently carried out[52]. This was based on a Phase 2 JNCC habitat survey, with specific reference to relationships between the gross morphology of the structures and the ecological diversity of the communities they currently support.

Evaluating ecological communities on existing rock rubble structures on Portland Breakwater, Dorset

The ecology on the structures was broadly similar to that of surrounding natural rocky shores, being composed of local Portland limestone and having been in place for several decades. Rubble structures with a varied range of rock sizes, and a shallower inclination, supported a greater range of community types. The range of wave exposures created by the breakwaters at Portland has increased species composition in this area. These kinds of observations provide information on what species might be expected to colonise any future structures built in the area, and which design features appear most critical to biodiversity.

4.5. This stage usually involves initial consideration of high level options or alternatives to achieve a particular objective or meet the identified need. This is the 'ideas stage' where, ideally, opportunities for enhancement are identified. Importantly, before examining opportunities to enhance, a critical question should be whether there are soft defence alternatives (in the case of planned hard structures); this is not the focus of this guidance document but should be examined in line with the mitigation hierarchy to first avoid impacts as far as possible.

TIP: Consider the opportunity for enhancement and all possible alternatives as early as possible – it may become a planning requirement and it is likely to be cheaper, easier and more effective to embed the concept of enhancement from the beginning of a project.

Parties involved

4.6. Identifying enhancement opportunities at the pre-planning and feasibility stage would typically involve the asset owner or proponent. If lacking in-house skills, the asset owner may already start to engage external specialists to consider possible proposals. This may include engineers, architects, academics, ecological and planning consultants. Within the EA, Area teams or NCPMS should contact NEAS and FRB at this stage to consider environmental and social risks, and opportunities as part of structure designs. In both cases, it is recommended that marine scientists (i.e. ecologists and geomorphologists) are also engaged to assist.

Key questions and advice at Stage 1

4.7. Table 2 provides information on questions that should be posed at this early stage in order to help identify what enhancements might be possible.

Chesil Beach, Dorset

Table 2: Questions, advice and decisions to be made at Stage 1: Pre-planning stage.

PLANNING QUESTION	ADVICE IN RELATION TO ENHANCEMENT	RECOMMENDATIONS FOR NEXT STAGE
Is there benefit in considering ecological enhancement in this particular structure?	There are very few cases when there is no benefit in exploring opportunities for ecological enhancements.	Engaged a marine scientist to examine proposals. Ensure you have a good understanding of legislation and planning policy in relation to ecological enhancement requirements.
Where in the tidal frame is the structure to be built/ refurbished?	Consider the diversity and type of species that enhancement might benefit. If the structure is inundated on average less than two hours a day there will be fewer species able to colonise the structure.	Reach agreement with the design team on whether you are exploring general or specific enhancements (Section 2).
What is the likely shape/ form of the structure?	How could you maximise variation in the surface of the structure? Flat, smooth surfaces will typically offer fewer habitats than rough, complex ones.	To encourage greater biodiversity, start to discuss whether it is practical to include more variation in the surface of the structure.
What materials to chose?	Consider naturally rough over smooth.	List materials options, and consider benefits of each alongside costs. Speak to materials suppliers to identify the options; is artificial texturing feasible (e.g. of concrete)?
How exposed to wave action is the structure?	More exposed – less diversity.	If exposed, is there opportunity to create shelter in a way that would also benefit the longevity of the structure?
Are there designated coastal habitats and/or protected species (locally and regionally)?	Check for the presence of habitats/species of conservation importance (e.g. SSSIs, Natura 2000 2000 marine conservation zones etc.) and identify legislative requirements associated with these (e.g. appropriate appraisals etc.)? Examine any opportunity to support or enhance these species and/or habitats, and consult with Natural England, CCW and local Wildlife Trusts.	Conflicts between the initial development objectives and protected habitats/species can be avoided through careful siting, design and implementation of works; examine the development alternatives that avoid impacts to negate the need for lengthy legislative procedures; consider how enhancements could deliver conservation outcomes before submitting the outline planning application.

PLANNING QUESTION	ADVICE IN RELATION TO ENHANCEMENT	RECOMMENDATIONS FOR NEXT STAGE
What high-level social or economic issues might constrain enhancement design?	Consider other users in the locality. What aspects of design might conflict with these users?	Register a list of users and needs, and what restrictions this may potentially place on the design of enhancements.
Are there other constraints or environmental concerns that need to be considered (e.g. invasive species)?	Discuss environmental concerns with users and statutory authorities alongside social and economic concerns.	Register a list of users and needs, and what restrictions this may potentially place on the design of enhancements.

Examples of considering ecological enhancement at Stage 1

4.8. **Seattle Seawalls Project:** this project was designed as a pilot study, as a pre-cursor to a later planning application (see Section 2.3 and Appendix B). Seattle City Council intends to use the results of the scientifically robust (i.e. two years of MSc research, GOFF/72) study to inform designs during the pre-planning stage of the application to re-build Seattle's sea walls.

4.9. **Isles of Scilly Harbour Extension Project**: Isles of Scilly Harbour Extension Project: This project was proposed by Cornwall County Council's Highways Department, where Halcrow Group Limited was appointed to oversee engineering and environmental aspects of the proposed work (Pinnington, pers. comm. 2011). The main aim of the initiative was to extend and modernise the two existing harbours connecting the Isles of Scilly, at St. Mary's, to the mainland, at Penzance. The approvals process for this project required a Harbour Revision Order (HRO) to be applied for and approved by the Marine and Fisheries Agency (now the Marine Management Organisation [MMO]) first, followed by a planning application. Ecological enhancements of the harbour re-development were agreed as part of the HRO approval process; prior to obtaining planning permission and marine management organisation licenses (i.e. FEPA/CPA licenses, now termed Marine Licences).

Granite rock rubble armouring, Penzance, Cornwall.

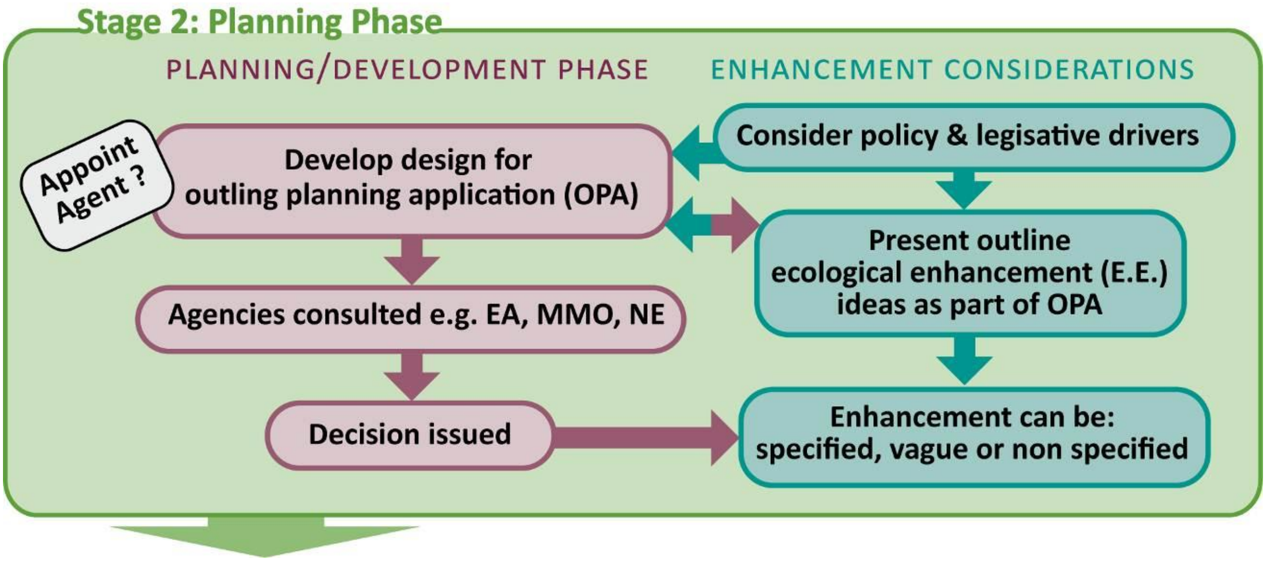
4.10. Under the HRO, various assessments were undertaken to identify impacts including statutory consultation. This resulted in a number of holding objections from statutory consultees. These were overcome by creating a Memorandum of Agreement (MoA), so that the objections could be withdrawn. The required enhancements in the MoA included: a) high-tide bird roosts, b) temporary and permanent bird ledges and c) creation of a MPA in the wider Mount's Bay area (See **Appendix B** for further details). The enhancements of the hard structures were part of a suite of ecological measures (which also included full seagrass surveys) that were required to establish a firm baseline that could be monitored during and after the works, where any required mitigation could be put in place.

4.11. Though promotion of these plans at the ICE Coasts, Marine Structures and Breakwaters 2009 conference, discussions began between the Universities of Exeter and Plymouth about other potential enhancement opportunities the Scillies Harbour Extension project could provide. If the Scheme had been approved, a concerted effort would have been made to secure research funding to create additional enhancements for intertidal and/or subtidal species which could have been scientifically tested.

4.12. **Sydney Harbour wall:** 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 (notably the city mayor). This resulted in the engagement of local experts (ecologists from the University of Sydney's EICC) who were subsequently involved in subsequent stages of the process, i.e. the design of artificial 'rockpools' and post-construction monitoring (see **Appendix B** for further details).

Ecological enhancement in Sydney Harbour through collaboration between North Sydney Council and local ecology experts.
(Photo: G. Chapman, EICC, University of Sydney).

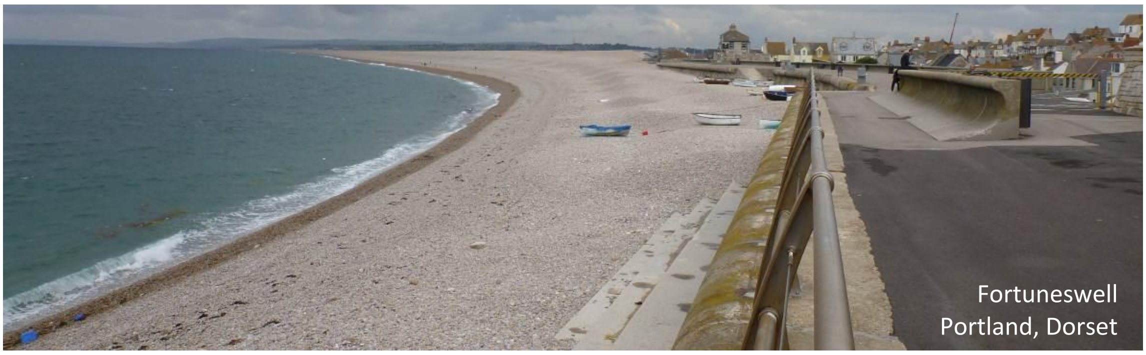
STAGE 2: OUTLINE PLANNING STAGE



4.13. Confirmation of available budget, engineering feasibility, potential planning acceptability and/or motivations of the asset owner may move the project from a pre-planning/feasibility stage (above) to the planning stage.

4.14. By this point, decisions have probably been made on whether suitable opportunities exist for ecological enhancement, and if so whether a general or specific approach is planned. However, in practice, ecological enhancement might be identified later by external consultees or planners as part of the mitigation solution when the plans are expected to have a significant adverse effect on the environment.

4.15. The implementation, design and construction details may not be decided with the contractor until the tendering and/or construction stage (below). However, at the end of the planning stage, ecological enhancement options have probably been discussed and evaluated, and preferred options may have been selected.



Parties involved

4.16. As the initial concepts start to evolve into design drawings, the breadth and depth of consultation needs to increase. There will be a need for internal discussions between the asset owner, the design, planning and environment teams, and with marine ecology specialists. It would also be beneficial to discuss the proposal with a planning officer. The role of the 'knowledge broker' to manage these interactions and maintain the focus of ecological enhancement as an outcome of the project is particularly important here; more information on the role of knowledge brokers is given in Section 3.1.

4.17. EA based schemes often include a degree of detailed design as part of the outline planning stage (or equivalent where no planning is required). Reasons for adopting a more detailed approach at this stage typically include: (i) a requirement for streamlining construction; (ii) to improve understanding of risk and costs associated with the scheme, and/or; (iii) a requirement as part of approvals under the Habitats Directive (Peacock, pers. comm., May 2011). This more detailed assessment and design improved the likelihood of a proposed scheme being approved.

Key questions and advice at Stage 2

4.18. The information collected at the previous stage (pre-planning) will have identified a range of possible options on the type of enhancements that may be viable. This should give an initial understanding of:

- The need for hard structures (over soft);
- The ecological, political and planning drivers for – and benefits of – integrating ecological enhancements in a particular location;
- The potential options for integrating enhancements, and to what degree these deviate from other initial planning options; and
- The potential locations and extent of ecological enhancements in the scheme.

BOX 9: Material Choice

The construction materials selected during the planning and detailed design stages can have implications for ecological potential. The type (and source) of material is also an important consideration with respect to aesthetics and cost.

The opportunities and feasibility of enhancement using material choice will largely depend on the specific engineering requirements and designs of the planned structure. Practically, material choice is influenced by suitability (durability/erodibility), availability and affordability. The use of timer is discussed elsewhere[53], but general considerations for rock include:

- Using materials with rough surfaces will generally be better for ecology;
- Using a range on material sizes (in rock rubble structures for example) will increase the amount of void space which can act as habitat for organisms (where engineering requirements permit);
- Materials that have a combination of horizontal and vertical surfaces, and which can hold water at low tide due to their shape, will also improve ecological potential;
- Incorporating porous, calcite rich materials (where feasible) can provide habitat for a particular suite of organisms (particularly rock boring species) that may otherwise be excluded. These organisms can also increase the roughness of the materials (through bioerosion) and thereby improve the habitat for other species.

Different communities developing on (clockwise): granite, limestone, natural slate and marine concrete after 3 years in the intertidal zone (Source: Coombes 2011).

TIP: Ensure that the full project team has been engaged by this point and that any conflicts of interest have been resolved.

Table 3: **Advice and decisions to be made at Stage 2: Outline planning stage**

PLANNING QUESTION	ADVICE IN RELATION TO ENHANCEMENT	RECOMMENDATIONS FOR NEXT STAGE
Have relevant statutory agencies, the planning authority and the public been consulted?	Engage the authorities/decision makers and public with the development of the scheme as a whole. This can avoid problems or objections arising later on.	Keep relevant statutory agencies informed. Arrange a site meeting to discuss any objections. Consider the need to build trials at detailed design.
Has a design for the structure been developed for outline planning?	Have the designers considered recommended ecological enhancements? Are these requirements specific, vague or non-specified (see Table 1)? Would minor changes now provide the same results for less money?	Identify who is championing ecological enhancement within the scheme. Decide what information is helpful to support the planning application.
Have the material choices for the design been agreed?	Consider the alternatives for construction materials, their benefits and limitations for ecology in the context of the engineering design.	See **Box 9** for advice on material choice.
Do the team agree on the benefits and potential for ecological enhancement?	Examine perceived barriers such as cost and time.	Consider possible alternative designs to accommodate perceived concerns.
How easily can the initial designs be built? Are they feasible? What might the additions costs be?	If there is Early Contractor Involvement, run initial concepts past them.	Include outline ecological enhancement ideas as part of the contract specification.

Examples of considering ecological enhancement at Stage 2

Case Study 1: Shaldon and Ringmore: terms of the planning conditions

Planning approval at the outline planning stage for the EA Shaldon and Ringmore Tidal Flood Defence was granted subject to planning conditions. These related to aspects of the development not yet specified due to delays on technical matters, on-going consultations/landowner negotiations; the specific design of ecological enhancement measures had not been agreed at the end of the outline planning stage.

The enhanced wall at Shaldon, Devon. Niche habitat and textured panels were incorporated at the base of the wall.

The planning permission conditions stated that "ecological mitigation was to be carried out in accordance with the submitted Environmental Report". The Environmental Report 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, discussed in the sections below.

Case Study 2: Broomhill Sands Coastal Defence Scheme

During the planning stage for an improved coastal defence scheme at Broomhill Sands, Sussex, the EA was required to conduct a WFD Mitigation Measures Viability Investigation. This was one of the first investigations of such a scheme using the new Mitigation Measures Viability Investigation Template. Although the template is designed for an entire waterbody, it was used specifically to identify whether mitigation measures were viable for the scheme extent (Peacock, pers. comm., 2011).

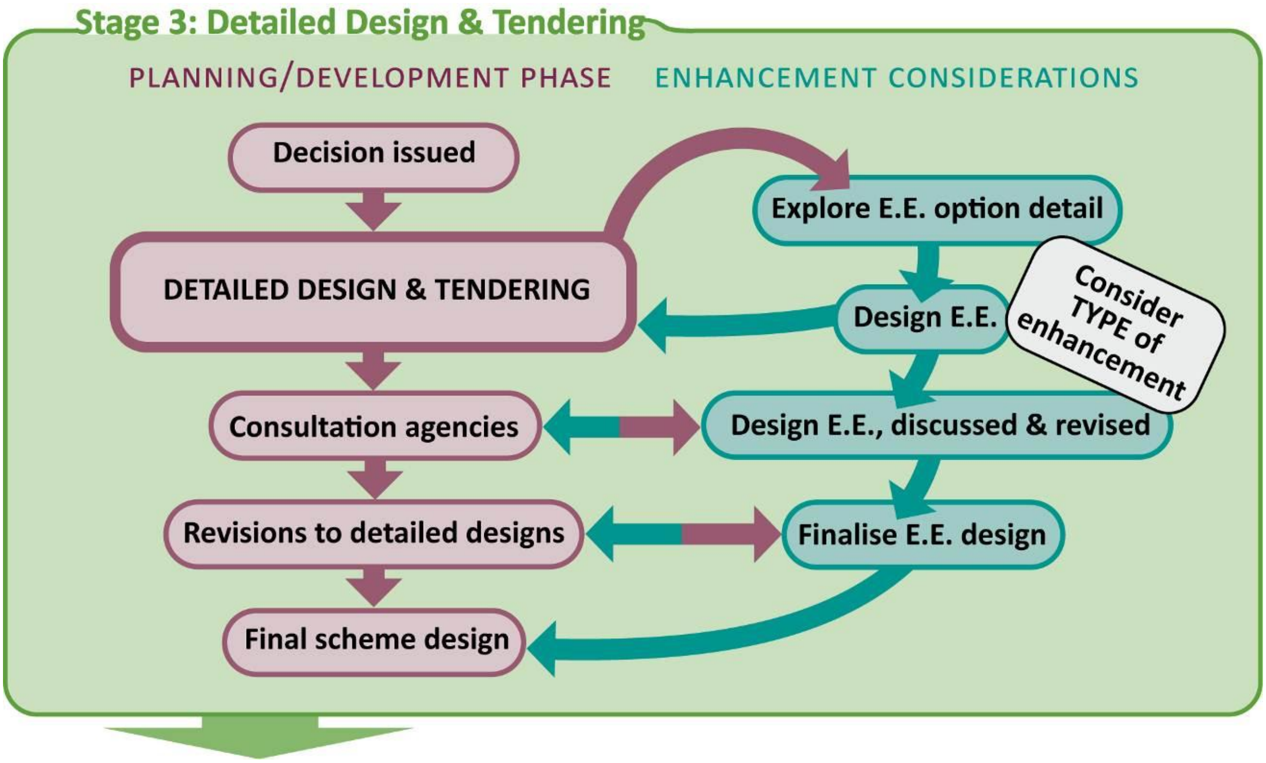
The outcome of the assessment was that no specific ecological mitigation measures were required, and all measures adopted are those related to mitigating the effects of the scheme against adverse hydromorphological impacts. However, the investigation report[54] notes that there may be ecological benefits through the introduction of rock in providing invertebrate habitat, but that there was not sufficient research in this area at present to support this.

One of measures specified as a mitigation option for HMWBs under the WFD is to preserve and where possible enhance ecological value of marginal aquatic habitat, banks and riparian zones[55]. This has the potential to support enhancement as part of WFD compliance, and should be fully explored as part of Mitigation Measures Viability Investigations. During this process, the following steps are recommended:

- Use this guidance and examples discussed as a preliminary source of information;
- Draw on any new studies that emerge providing relevant and sufficient evidence on enhancement designs appropriate to the particular scheme in question; or
- Where no sufficient data exist, consult specialist marine scientists to inform the investigations, or if time and funds permit, conduct a locally-relevant pilot study of possible enhancement designs.

TIP: **If there sufficient evidence to support particular enhancement designs for a scheme, specialist marine scientists should be consulted at this stage where possible and, ideally, pilot investigations carried out to test and identify viable options on a scheme-by-scheme basis.**

STAGE 3: DETAILED DESIGN AND TENDERING STAGE



4.19. The preferred arrangement for many flood risk related infrastructure projects is to have the detailed design element fully specified and approved prior to tendering by contractors. This may be approved at the outline planning stage (or equivalent where the formal planning process is not required), or in Stage 3 prior to tendering. As such, the normal pathway is design > tender > build, rather than tender for both the design and build phases together. In some cases, the detailed design is not approved prior to tendering and the tendering process is for 'design and build'.

4.20. Unless it is a design and build contract, this will be the stage when the project goes out to tender to bring on board a contractor. It is necessary to include at least outline ecological enhancement ideas or requirements within the contract specification to ensure the costs related to the actions are understood. In the 'design and build' approach, the bidding contractors have to base their bid on the information provided, leaving scope to cover changes that may arise as a result of the detailed design process. If these changes were substantial then a compensation event would be recorded to increase the money available for the contractor to carry out the extra work.

4.21. Planning approval is often accompanied by a set of conditions that have to meet and may require significant alterations to aspects of the project. The team will need to reconsider the proposed enhancement measures in light of these planning conditions:

- If planning permission was declined then any redesign may affect or be related to the locations and nature of the proposed enhancement measures;
- In making any changes to the initial enhancement ideas, the team should be aware of expectations from consultation agencies or other interested parties. Previous correspondence and reference to other examples when presenting outline designs may become redundant as the design is finalised;
- Outstanding issues on detailed design will need to be discussed with both the design team and the contractor at this stage.

TIP: If an operational trial is being designed to test an enhancement feature (e.g. a particular texture, or artificial pool), ensure sufficient 'replication' of the feature in the design to so that the trial is scientifically robust.

Parties involved

4.22. All previous stakeholders are likely to be involved at this stage. However, the emphasis on those who are involved will shift. The degree of input from the design team will depend on the changes required to accommodate planners requests. If any required changes are unlikely to affect the locations, number and form of the enhancement then emphasis should shift to the contractor and coastal ecologists involved in the project to discuss (in detail) how the final enhancement designs will be constructed. The planning authority will need to sign off the final designs, and the construction of trial panels at either this stage or during the construction stage may be needed to facilitate this process, particularly if the structure is visible to the public or associated with an area or feature of historic interest.

4.23. This stage may require consultation with external organisations or stakeholders, particularly subcontractors or suppliers of materials. If decisions are made to incorporate pre-cast units into the structure, for example, engagement will be needed with the suppliers to discuss material type and surface finish.

Key questions and advice at Stage 3

4.24. Detailed design is a crucial stage involving multiple partners trying to resolve political, community and technical issues within a short time-frame to ensure construction starts on time and on budget; there is the potential for ecological enhancements to be side-lined or ruled out at this stage. Unless there is an obligation to deliver them, it is important that someone has clear ownership to deliver them. Cost of enhancements, easy wins, and the benefits the enhancements may need to be restated at this stage. Important questions and advice at the detailed design stage are shown in **Table 4**.

Table 4: Key Questions, Advice and decisions to be made at Stage 3.

KEY QUESTION	ADVICE IN RELATION TO ENHANCEMENT	RECOMMENDATIONS FOR NEXT STAGE
Is the contractor able to develop and build the proposed ecological enhancements as expected – can the planned enhancements be built in practice?	Try to engage the contractor as early as possible. The contractor may plan to use a sub-contractor to build the particular section of defence of interest to you.	Consider test panels to investigate ease and cost of incorporating enhancement features and to satisfy concerns of the contractor, design team and other stakeholders.
Where and at what tide level on the structure should enhancements be positioned?	This question should have been addressed by this stage; however, if planning refusal, new modelling data or some other external factor has led to a change in project design the suitability of the proposed enhancement should be re-considered. Ensure that marine scientists are kept on-board throughout project development.	The questions regarding location and type of enhancements should not need to be revisited after this stage.
Are the enhancements likely to be more or less costly at this stage?	Consider the context in which the enhancement is being built. Is there an obligation to deliver these, are they part of the mitigation package and will they bring a measureable ecological improvement?	If designs and outcomes are still vague, can specific detailed be added so that the benefits of the enhancement are more measurable? Rather than over-designing the enhancements at this stage, are there easy/cheap wins (e.g. 'general enhancements') that demand little consultation?
If specific enhancements are planned (e.g. niche creation), how many of these be used or permitted?	Investigate what other requirements there might be on the area of the structure where the enhancements will be incorporated. For example, any potential siting restrictions due to drains and storm valves.	Be aware of other demands for space and late additions to the structure. As well as restrictions, these may provide opportunities, adding to the complexity of wall structure and providing habitat niches in themselves for example.
How, why and what to monitor after construction?	Objectives and targets related to the enhancements should be decided in advance.	Consider what will be monitored, by who and why. The targets and monitoring against these may potentially be included in the contract specification for the contractor to sub contract out and ensure delivery.

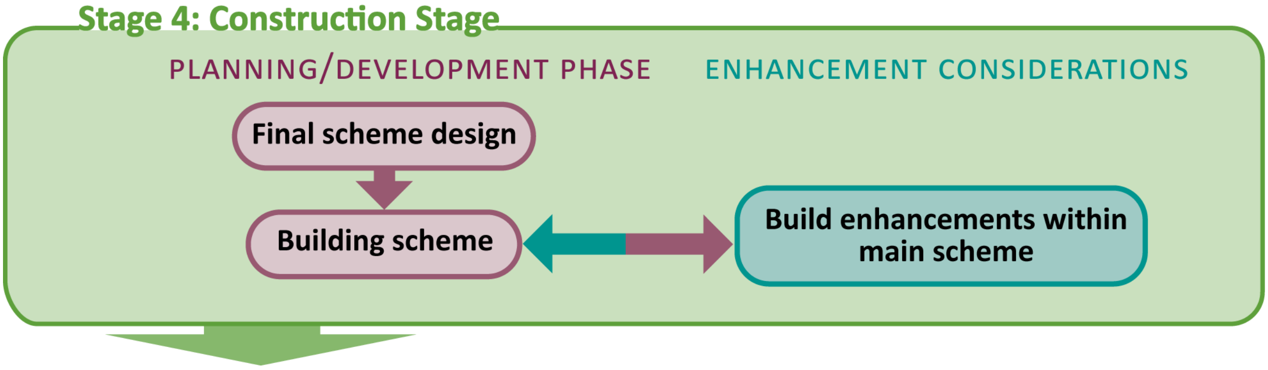
Examples of considering ecological enhancement at Stage 3

Shaldon and Ringmore Tidal Defence Scheme: Ecological enhancements were required (through the planning approval process) for the scheme, although the nature of enhancements was not specified in the final approved plans. Extensive discussions about enhancements took place during the detailed design phase of this project, initially in-house and subsequently involving local experts in ecology and geomorphology. Specific advice was given via this consultation on which sections of the scheme enhancement would be most appropriate (involving a site visit with all relevant parties) and subsequent recommendations on the specific enhancement designs.

Different types of enhancement were replicated within the structure at Shaldon to ensure a scientifically robust experimental design. Replicates are needed to test whether different treatments lead to consistent ecological outcomes.

At this stage, key recommendations for the detailed design were to focus efforts on establishing a scientifically robust design that would provide a useful experimental trial to inform future works, including careful consideration of where to locate the enhancements (see **Appendix B** and **Box 10** for details of the enhancements tested as part of this scheme) and the level at which enhancement features were replicated within the structure. A key learning outcome of this process was that a knowledge broker (see **Box 7** above) was central to moving the team from idea generation to final design approval, and ultimately construction. Lastly, we recommend that future projects decide on enhancements earlier in the design process, as the designs were approved immediately before construction started.

STAGE 4: CONSTRUCTION STAGE



4.25. The construction stage may present a new set of questions as detailed designs are put into practice. Although many variables have probably been discussed with the project team, difficulties in on-site construction and uncertainties in how environmental conditions will change in light of the new structure may present additional challenges (see **Box 9** below for an example of such unforeseen changes). As construction methods change and designs are altered it is difficult to cover every eventuality, especially on large complex projects.

4.26. When construction is happening, consider again the monitoring arrangements for the ecological enhancements. Monies may be available as part of the landscaping arrangements or structural defects period to fund short term monitoring arrangements. However for longer term funding additional sources may be needed (see Stage 5 below).

Parties involved

4.27. If all stakeholders have been consulted by this stage, the contractor should be able to continue with some direction and advice from the marine scientists to account for unexpected questions and challenges arising during construction. Depending on the accessibility of the scheme and visibility of the enhancements, members of the public may take a interest in the enhancements. The project team should consider the opportunities for publicising the works and the ecological benefits.

4.28. Most large civil engineering schemes, including EA works, appoint an Environmental Clerk of Works (ECoW) for the construction stage. Broadly, the role of the ECoW is to monitor construction to minimise environmental impact and check the implementation of the actions identified in the Environmental Action Plan (EAP). Opportunities may arise during construction to extend and improve the enhancements which were not considered during planning and design stages. As the ECoW is frequently on-site, they may be best placed to maintain dialogue with the marine scientists and project team on the enhancements as the scheme develops.

Key questions and advice at Stage 4

4.29. Important questions and advice at this stage are included in **Table 5**, and an example of some of the issues arising during the construction stage of a completed operational ecological enhancement trial are discussed in **Box 10**.

Table 5: Key question and advice in relation to the construction stage.

KEY QUESTION	ADVICE IN RELATION TO ENHANCEMENT	RECOMMENDATIONS FOR NEXT STAGE
Has the contractor been able to produce the enhancement measures on-site, as expected?	Alterations to the original design may be required if practical constraints arise. Some compromise may be required if designs prove impractical; prior testing and discussion with the contractor should minimise the chances of this.	If changes are needed, consult with marine scientists as this may affect outcomes and the proposed monitoring plan.
What, how and why to monitor after construction?	This should relate to the earlier decisions on specific or general enhancement measures, any target species, and the expertise, budget and reporting requirements associated with the monitoring. A monitoring plan should be in place.	Complete monitoring plan to include in the Health and Safety file or Operations and Defects file. Seek funding to enable monitoring over a sufficiently long period of time to adequately measure ecological responses to the enhancements. Ensure results relate/ feed into wider monitoring programmes and are used to inform subsequent schemes.

Examples of enhancement issues during construction

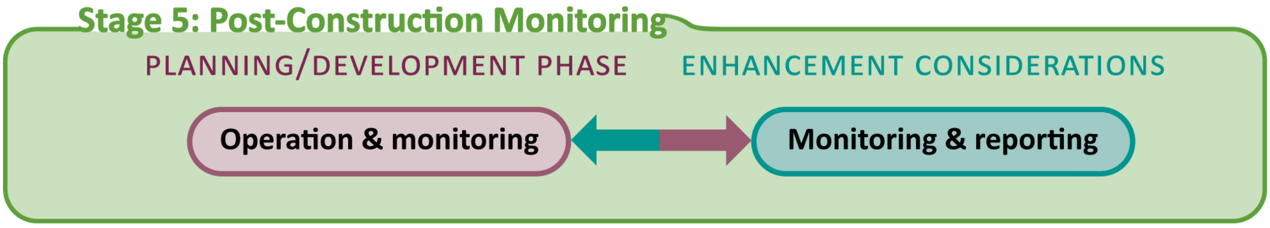
BOX 10: Construction Issues at Shaldon

The section of Shaldon and Ringmore Tidal Flood Defence Scheme in which ecological enhancements (see Appendix B and **Figure 2**) were incorporated was built between May 2010 and August 2010. A number of practical issues arose during the construction period, included:

- The position on the flood defence wall at which the enhancement features (habitat niches) should be placed. Whilst there was a desire to place enhancements as low on the structure as possible (i.e. lower in the tidal frame where more species are likely to colonise), there was some uncertainly of the likely level of the (sand/silt) beach in front of the wall post-construction. Enhancements were therefore placed at two levels on the wall (at the base, and slightly raised), providing a comparison of ecological responses to the same enhancements at different tide levels, and also allowing some contingency against smothering of the lower sections following beach adjustment.
- Ground works during the construction of the flood wall identified that additional weep vents would be needed. These features restricted the number of enhancement features that could be used (i.e. those which would be scientifically comparable without influence of drainage water for example, see photo below). As a result, the number of replicates of each different enhancement originally planned had to be reduced.
- There was a great deal of variation in the permeability of the mortar used by the stone masons in the construction of the wall. As a result, the ‘rockpool’ type features (**Appendix B**) did not perform as expected and did not hold water at low tide. Sealant was used to rectify this problem.
- One of the planned enhancement treatments consisted of fine-scale (millimetre) grooves in the wall mortar which had been previously used successfully on marine concrete. However, the course texture of the mortar meant that there was little difference between these treatments and the ‘control’ (i.e. un-modified) areas of mortar, requiring reconsideration of the planned monitoring.
- For more details, see the internal NEAS team ‘Best Practice Guidance’ on this project: “Good Practice Note – Shaldon Tidal Flood Defence Scheme”

An (unplanned) need to include drainage vents in the structure meant that some of the enhancement features were lost from the original trial design; over-replication in operational trials should help minimise such unforeseen problems arising during the construction stage.

STAGE 5: POST CONSTRUCTION AND MONITORING STAGE



4.30. An ownership file is required for most civil engineering works upon completion. This provides a repository for the as-built drawings and other information for the operation of the scheme. There is the opportunity here to include information on the monitoring arrangements of the enhancement measures within this document.

4.31. The EA usually requires the contractor to be responsible for a one-year maintenance and defects period on completion of the works. Monitoring of the performance and ecological responses to the enhancements should therefore be included within the budget allocated to this year where possible. Including this form of monitoring will ultimately increase costs, and so must be set against the scheme benefits such as coastal protection and/or reducing flood risk.

4.32. Additional funding should be sought to continue monitoring over a longer period of time. This is important not only to contribute to the existing knowledge base of ecological enhancement options and outcomes, but may also be necessary before any perceived ecological gains are detected (in comparison to ‘un-enhanced’ parts of the structure). Reference to baseline ecological surveys undertaken at Stage 1 should be made here. Funding may be sought from research institutions (i.e. universities, NERC) that have dedicated funding streams for business collaborations, or are able to tether monitoring to existing or planned research projects. Local conservation groups (e.g. Wildlife Trusts) may also be interested in monitoring the structure, and should have already been engaged in the scheme during earlier stages of planning.

4.33. Dissemination of the results of monitoring undertaken (both internally and publically) is equally as important as the monitoring itself. Difficulties and solutions of including enhancements in the scheme should be reported alongside the ecological outcomes of the particular measures adopted to help inform subsequent scheme designs.

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Appendix B. Examples of ecological enhancement trials ordered by the spatial scale of enhancement goals (from species to habitat).

INCREASING SPATIAL SCALE OF ENHANCEMENT GOALS (i.e. SPECIES TO HABITAT)

Ecological Aim	Type of Study	Year	Location	Type of structure	Scale of Enhance -ment	Enhancement Details (material & design)	Outcomes	Source
Target Organism: Barnacles; ISD[1]	Experimental	2008–2010	Cornwall, UK	Test panels (attached to rock platforms as analogues for horizontal structures)	mm–cm	Granite, Limestone & Concrete panels; concrete with plain-cast, smooth, grooved (mm) & exposed aggregate (mm – cm) surfaces. Duration: after 1 yr.	Significantly different settlement & recruitment between treatments (highest on grooved surfaces).	Coombes et al. 2009, 2010 Website: www.exeter.ac.uk/coastaldefencesbiodiversity
Target Organism: Limpets	Experimental	2010	Azores, Portugal	Vertical basalt seawall	cm	Holes (12 & 24 mm dia., 10 mm depth) drilled into a basalt seawall to test potential for enhancing an exploited species (*Patella candei*). Duration: after 4 months.	Numbers of limpets were significantly higher in areas with holes compared to control areas due to enhanced adult migration & recruitment of juveniles.	Martins et al., 2010
Target Organism: Pacific Salmon; ISD	Experimental	2008–2010 / on-going	Seattle, Wash., USA	Test panels (attached to concrete seawalls)	cm–m	Concrete panels with smooth & rough (cobble) surfaces, attached vertically, horizontally & sloping. Concrete troughs as pool habitat. Duration: after 1 yr.	Different organisms showed different responses (e.g. mussels preferred cobbled compared to smooth).	Simenstad, 2009; Goff, 2010. Website: sites.google.com/a/uw.edu/seattle-seawall-project/design
Artificial pools; ISD	Experimental	2011 / on-going	Various, UK	Rock rubble, disused docks	cm–m	Use of 'BIOBLOCKS' to increase meso-scale habitat complexity.	Preliminary results not available. On- going monitoring.	Website: urbaneproject.org

INCREASING SPATIAL SCALE OF ENHANCEMENT GOALS (i.e. SPECIES TO HABITAT)

Ecological Aim	Type of Study	Year	Location	Type of structure	Scale of Enhance -ment	Enhancement Details (material & design)	Outcomes	Source
Target Organism: Purple Sandpipers	Scheme proposal (as mitigation)	2008–2010	Penzance, Cornwall, UK	Rock armour / pre-cast concrete wall	cm–m	Provision of temporary roosts in a suitable locations during construction, following 3 year bird surveys. Rock armour placed unevenly, providing foraging habitat in void space post-construction. Ledges created within pre-cast concrete sea wall (at different tide levels) and some rock armour placed at least 2m above highest tides to provide roosting sites.	Not tested due to project funding revoked.	Penzance Memorandum of Agreement for the Penzance Harbour Revision Order (2005).
Target Organism: Cup coral	Scheme proposal (habitat provision)	2008–2010	St. Mary's, Isles of Scilly, UK	Pre-cast concrete units	cm–m	Incorporation of suitable substrate for cup coral, specifically the provision of adequate cracks and fissures.	Not tested due to project funding revoked.	Penzance Memorandum of Agreement for the Penzance Harbour Revision Order (2005).
ISD	Operational Trial	2009 / on-going	Sydney Harbour, Australia	Vertical concrete seawall with sandstone block façade	cm–m	Creation of cavities (60 x 30 x 30 cm) in sandstone facing to create pool habitat. Duration: after 1 year.	Invertebrate species richness was increased after 1 year, with pool biodiversity greater than adjacent walls.	Chapman & Blockley, 2009 Website: http://eicc.bio.usyd.edu.au/research/anthropogenic_disturbances/

INCREASING SPATIAL SCALE OF ENHANCEMENT GOALS

Ecological Aim	Type of Study	Year	Location	Type of structure	Scale of Enhance -ment	Enhancement Details (material & design)	Outcomes	Source
ISD	Operational Trial	2010 / on-going	Shaldon, Devon, UK	Vertical concrete & sandstone seawall	mm–cm	Cement mortar textured to compare colonisation on smooth surfaces & surfaces with holes (1.5 cm dia.), grooves (mm), & artificial rock pools.	Preliminary results not yet available. Monitoring to commence in 2010.	Website: www.exeter.ac.uk/coastaldefencesbiodiversity
ISD	Experimental	2008–2009	Ijmuiden, Netherla-nds	Concrete block rubble breakwater	mm–cm	Concrete slabs (75 cm x 25 cm) attached with different scales/types of texturing (Fine and coarse roughness, holes and grooves). Duration: after 15 months.	Rough surfaces and holes colonised by green algae quicker than smooth; mussels colonised grooves faster.	Borsje et al. 2011
ISD	Experimental	2005	Elmer, Sussex, UK	Test panels (attached to rock rubble breakwater)	cm	Concrete panels exposed with smooth surfaces & with holes (1.5 & 3 cm dia. x 2 cm depth). Duration: after 1 yr.	Holes increased diversity of species two-fold compared to smooth panels.	Moschella et al. 2005 Website: www.delos.unibo.it/
ISD	Experimental	2009	Lysekil, Sweden	Concrete foundations for wave energy devices	cm	Rectangular holes (12 x 15 x 30 cm) holes cast in subtidal concrete units. Duration: after 3 months.	Fish & crab abundance was significantly higher on units with holes than those without.	Langhamer & Wilhelmsson, 2009

[1] – ISD = Increase species diversity

CASE STUDY: Shaldon and Ringmore Tidal Defence Scheme

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. Funding was provided by Defra with approval from the South West Regional Flood Defence Committee.

The University of Exeter and University of Plymouth were engaged to explore opportunities for ecological enhancement during the design process (see Section 4). As a result, a trial was designed to test different enhancement options on two adjacent vertical concrete walls faced with local stone with mortar jointing (Figure X). The trial involved manipulating widened areas of mortar (roughly 15 x 15 cm) between blocks in four different ways:

- **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 (see photo below). These features were designed to function in a similar way to larger scale pools built in a vertical wall in Sydney Harbour, Australia.
- **Control** : Areas of mortar were left as-used for the rest of the wall. Such control areas are critical to enable valid evaluations of the influence of the other treatments on ecology in comparison to unmodified sections of the structure.

The treatments were spaced at equal distances along two 15 metre sections of wall. In total, 15–20 of each treatment were built into the structures to provide enough 'replicates' for robust scientific comparisons. Early observations suggest that the treatments are being colonised by cyanobacteria and foliose algae, and that macro-fauna (snails and limpets) are responding positively to the enhancements.

Appendix C: Policy instruments supporting ecological enhancement of hard coastal structures

LEGAL FRAMEWORK	SCOPE AND RELEVANCE TO ECOLOGICAL ENHANCEMENT	OPPORTUNITIES TO FACILITATE ECOLOGICAL ENHANCEMENT OF HARD COASTAL STRUCTURES
European (UK transposition)		
Water Framework Directive (2000/60/EC)	Probably the main legal frameworks under which ecological enhancements will be delivered. Requires all waterbodies to reach 'good status' by 2015 based on environmental objectives and ecological targets for surface waters. Heavily Modified Waterbodies must achieve 'good ecological potential'. For each river basin district a River Basin Management Plans are being developed, which include a programme of measures forming the basis to achieve these targets (Articles 11 and 13). Remediation is required for the damage caused to waters covered by the Water Framework Directive.	Ecological enhancement could be adopted as a mechanism within the programme of measures for the achievement of the required ecological status, taking into account results of the river basin analysis required under Article 5 of the WFD. Ecological enhancement can function as a measure to mitigate against possible deterioration of ecological quality from proposed projects or plans. e.g. http://evidence.environment-agency.gov.uk/FCERM/en/SC060065.aspx
Council Directive on the conservation of natural habitats and of wild fauna and flora ("**Habitats Directive**") 92/43/EEC & Council Directive on the conservation of wild birds ("**Birds Directive**") - 79/409/EEC	The main aim of this Directive is to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements. Under Article 6(4), adverse effects on the integrity of Natura 2000 sites are permitted only if compensatory measures are taken.	Compensatory measures aim to provide a similar level of natural resources and services at an alternative site, or at a part of the original site not impacted by the project concerned. For European Protected Species, enhancement could be used to avoid detrimental impacts of development at either a population or biogeograhical level. However, coastal intertidal rocky habitats and species are not designated features so ecological enhancement of hard coastal structures is unlikely to be suitable as mitigation measure.
EC Directive on **EIA** (85/337/EEC) and (97/11/EEC)	One of the main legal frameworks under which ecological enhancements will be delivered. The Directive establishes a systematic process to predict and examine the environmental consequences of proposed development actions in advance. It provides the foundations of mitigation and compensation approaches. Article 5(3) requires that developers submit 'a description of the measures envisaged […] to prevent, reduce and where possible offset any significant adverse effects to the environment'.	Mitigation is often used to mean minimisation, such as limiting or reducing the degree, extent, magnitude or duration of adverse impacts; ecological enhancement has opportunities here.

LEGAL FRAMEWORK	SCOPE AND RELEVANCE TO ECOLOGICAL ENHANCEMENT	OPPORTUNITIES TO FACILITATE ECOLOGICAL ENHANCEMENT OF HARD COASTAL STRUCTURES
European Directive (2001/42/EC). "**SEA Directive**"	Article 5(1) of the Directive stipulates that the assessment report should identify, describe and evaluate likely significant effects on the environment. Annex I specifies that the report should provide information regarding 'the measures envisaged to prevent, reduce and as fully as possible offset significant effects on the environment of implementing the plan.'	The Directive provides opportunities for consideration of measures to enhance as well as mitigate against significant impacts on the environment. SEA corresponds well with large scale landscape planning and anticipated landscape change. The SEA procedure can illuminate connections between planning policies and environmental change, highlighting potential impacts of plan implementation and providing opportunities to propose strategic mitigation/enhancement through project implementation.
Environmental Liability Directive (2004/35/EC)	This Directive aims to hold operators whose activities have caused environmental damage financially liable for remedying this damage; this will result in increased levels of prevention and precaution. Article 2(1) states that damage to protected species and natural habitats include activity that has significant adverse effects on reaching or maintaining the favourable conservation status. Article 7(1) states that the operator has to identify potential remedial measures to offset the environmental damage and submit them to the competent authority for approval.	Under this Directive damage to biodiversity is limited to species and habitats protected under EU legislation, and so is unlikely to be the primary driver of ecological enhancement measures. Enhancements to can, nevertheless, be considered when planning remediation measures.
UK Legislation and Statutory Regulations		
Marine and Coastal Access Act 2009	Marine Policy Statements, Marine Plans and Marine Conservation Zones provide a strategic, integrated and forward-looking framework for achieving biodiversity targets, with planning and licensing delivered via the Marine Management Organisation.	The MMO already has a statutory duty to have regard for conserving biodiversity, to comply with the Wild Birds and Habitats Directives and to further MCZ conservation objectives. The new strategic approach should make it easier to examine the likely cumulative impacts of implementing proposals in all industry and conservation sectors and the need to address biodiversity loss through all developments.
Countryside and Rights of Way Act (CROW) 2000	Government must *'have regard...to the purpose of conserving biological diversity'* (i.e. UK BAP Priority habitats and species). Conserving should include *'the restoration or enhancement of a population or habitat'*. Public bodies, including planning authorities, must also: *'further the conservation and enhancement of SSSIs.'*	The Biodiversity Strategy for England states in relation to the CROW duties that '*construction, planning, development and regeneration have minimal adverse impacts on biodiversity and enhance it where possible'*.

LEGAL FRAMEWORK	SCOPE AND RELEVANCE TO ECOLOGICAL ENHANCEMENT	OPPORTUNITIES TO FACILITATE ECOLOGICAL ENHANCEMENT OF HARD COASTAL STRUCTURES
UK Biodiversity and Planning Policy		
Environment Act 1995	National Parks Authorities (NPA) duty/function for '*conserving and enhancing the natural beauty, wildlife and cultural heritage*' of National Parks.	Duty to *'conserve'* could be used by NPAs and EA to seek compensation in relation to developments adversely impacting National Parks or water features respectively.
Harbour Revision Orders (Harbours Act, 1964)	Managed by the MMO, where applicants apply to the MMO for permission to construct a new harbour and/or to improve, maintain or manage an existing harbour. 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. This resulted in a number of holding objections from statutory consultees. See the Isles of Scilly Harbour Extension example in Section 4 above.
Planning Policy Statement 9: Biodiversity and Geological Conservation (PPS9)	A key planning policy tool for protection of biodiversity in England. PPS9 states that where '*significant harm cannot be prevented, adequately mitigated against, or compensated for, then planning permission should be refused'*. Requirement for biodiversity enhancement in new development. PPS9 applies not only to Habitats and species protected by the Wildlife and Countryside Act and the Habitat Regulations but also Regional and Local BAP habitats and species.	PPS9 sets a relatively unambiguous planning policy requirement for mitigation and biodiversity offsetting where a development would result in *'significant harm'*, including at the coast. PPS9 advises planning conditions should be used to achieve this and may be implemented by the LA before planned developments will be approved.