A Tidal Energy Lagoon in Swansea Bay: optimising its value for biodiversity by creating an artificial reef

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Tidal Lagoon Swansea Bay plc (TLSB) proposes to construct a tidal energy lagoon. The structure will enclose an 11.5 km² tidal area. The lagoon wall will stretch for 9.5 km and incorporate up to 16 underwater turbines which produce 400GWh on a net annual output basis. The nature of the project requires the building of rock armour protected seawalls which will be placed on top of the soft substratum in Swansea Bay. It will hence add to the existing rocky intertidal and subtidal habitat in the area. The company aspires to optimise the design of the wall to promote biodiversity and create an artificial reef. TLSB collaborates with the SEACAMS project at Swansea University to explore options that would benefit the ecological value of the lagoon. The EU project SEACAMS (Sustainable Expansion of the Applied Coastal and Marine Sectors in Wales) is a strategic development project to integrate research and business opportunities around the coast of Wales.

Recommendations for the project were guided by the latest research on eco-engineering of coastal defence structures in the coastal and marine environment (URBANE project, 2013). They can be broadly separated into hard engineering solutions, which affect the nature and texture of the building materials, and soft engineering, referring to the creation of biogenic habitat features.

Surface texture: ridges, overhangs, rockpools and precast reef blocks

The design of artificial coastal structures has a major effect on the natural environment. The magnitude of the effect appears to be heavily dependent on the nature of the created structure, the location and the composition of the native flora and fauna at the time the artificial structure is created. The structural complexity of the building materials and the architecture play an important role for the number and diversity of animals and plants colonising the artificial material, and hence whether an artificial structure will eventually qualify as a reef. TLSB plans to add design features to the lagoon wall that mimic a rocky shore with a mixture of rock sizes, roughness and crevice sizes. Incorporating materials of different porosity can provide habitat for other organisms, especially rock boring species.

Artificial rockpools will be either attached to the lagoon wall or excavated from the rock armour. Recent studies demonstrated that adding experimental rock pools to a seawall will attract sessile and motile species, mitigate against species loss and promote biodiversity (Browne & Chapman, 2014).

Another method to improve the structural complexity of an artificial reef is the deployment of precast units. These are designed to attract particular species or to offer multiple habitat types. SEACAMS (Bangor University) have developed a large-scale habitat enhancement unit called the BIOBLOCK. The objective of the precast blocks is to provide additional habitat types that can be incorporated into rock armour, breakwaters groines and revetments at the

construction stage. TLSB is organising a public competition to create designs for precast blocks and will commission the construction and deployment of the winning models.

"Shell BioReefs"- shell filled gabions

In recent years engineering solutions have been explored that prevent erosion of coastal habitats, and in particular the loss of sand and mud. In the Netherlands gabion cages filled with fished-up oyster shells were mounted on silt in intertidal areas. Studies at Swansea University in collaboration the bioengineering company Salix showed that shell filled mesh bags attract a diverse coastal fauna within a short period of time, and that they have the potential of enhancing local biodiversity. The research is currently being up-scaled to improve the construction of shell gabions and mattresses, improve their environmental sustainability, explore their effect on the surrounding environment and understand the longer term benefits for biodiversity. TLSB plan to incorporate these shell gabions in the lagoon to maximise the environmental benefits.

Creating biogenic reefs

In engineering terms biogenic reefs are also referred to as "soft" engineering solutions. They include saltmarsh, seagrass, oyster and mussel beds and tube-worm reefs. These features offer protection from hydrodynamic impacts, retain sediment and reduce erosion, but they also promote biodiversity. It is for this reason that features like these are protected features under the EC Habitats Directive.

TLSB aspires to contribute to the recovery of oyster reefs in Swansea Bay. The company is interested in optimising local recruitment from rudimentary native oyster stocks (*Ostrea edulis*). The aim is to create reefs undisturbed by fishing impacts, and to focus on the promotion of biodiversity. The efforts would have knock-on benefits for the local oyster fishery by increasing the overall supply of oyster larvae and spat in the area.

In the long term, *Sabellaria alveolata*, the honeycomb worm, may benefit from the presence of the tidal lagoon walls. The tube worm is generally found in lower intertidal and shallow subtidal areas with relatively strong water movement. The main benefit of Sabellaria reefs is their function as 'ecosystem engineers': they provide a habitat for other species, thereby supporting a wide variety of invertebrates. They support a higher diversity of species than surrounding sandy areas. Artificial coastal defence structures have been found to provide settlement substrate similar to natural materials and were found to be colonised by large numbers of Sabellaria. TLSB will create habitats suitable for the colonisation of Sabellaria, and they will also engage in experimental work aiming to translocate and rescue Sabellaria aggregations that will be directly affected by construction work.

Seagrass meadows are declining at an unprecedented rate and therefore the ecosystem services they provide are also at risk including their role in fisheries production, biodiversity provision and nutrient cycling. SEACAMS and Salix Bioengineering are currently undertaking a collaborative project to investigate the potential to conduct restoration in the UK. To date, this project has successfully harvested and stored seagrass seeds with a view of growing

these in the laboratory for planting during 2014 and 2015. The proposed tidal lagoon area in Swansea Bay will create an environment of high shelter (low wave action) and contain sandy and muddy substrate, conditions potentially appropriate to seagrass. If water clarity becomes higher within the lagoon due to the reduced influence from the River Tawe and the River Neath then light availability could become sufficient to support seagrass growth. The lagoon area therefore has the potential to provide an opportunity for biodiversity enhancement through the creation of seagrass habitat in the future.

In summary, TLSB is planning to integrate the following design concepts into the tidal energy lagoon to improve its value for the coastal and marine environment:

- Avoid smooth rock material. Few organisms will colonise homogeneous surfaces and species colonisation rates will increase with surface roughness. Where possible, TLSB will use a mixture of hard and soft rock (where appropriate). Soft rock (e.g. limestone) will erode quicker than hard rock (e.g. granit) which will create surface roughness and habitat for attachment of marine organisms.

- Create rock pools, pits and crevices. Rock pools, pits and crevices provide refuges for intertidal organisms and support greater diversity than emergent substrata.

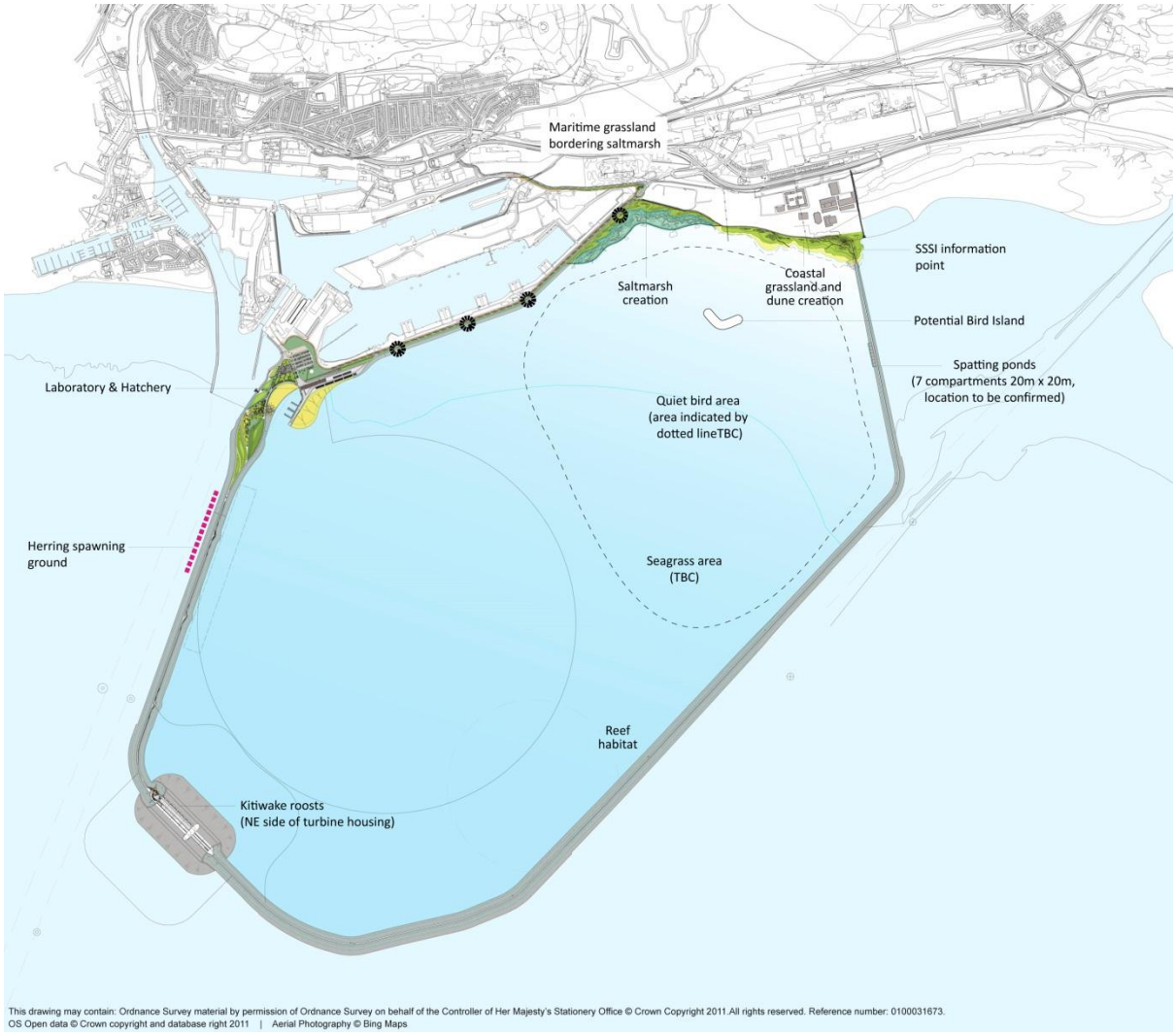
- Incorporate precast reef units in or around the lagoon wall. Artificial units that are designed to maximise the number of attracted species promote biodiversity and can provide protection from erosion.

- Facilitate 'soft' engineering. This includes the creation of saltmarsh, seagrass meadows, oyster and mussel beds and tube-worm reefs (Sabellaria). These features offer protection from hydrodynamic impacts, retain sediment and reduce erosion, but they also diversify the habitat.

In the long-term TLSB intends to develop projects that further investigate opportunities for tidal energy lagoons in terms of ecological enhancement as well as food and biofuel production (e.g. fish/bivalve and kelp cultivation).

URBANE project: http://urbaneproject.org/

Browne, M.A., Chapman, M.G. (2014) Mitigating against the loss of species by adding artificial intertidal pools to existing seawalls. MEPS 497: 119–129.



Tidal Lagoon Swansea Bay: proposed design indicating created habitats for wildlife.