THE POTENTIAL OF RESTORING MARINE HABITATS FOR MARINE NET GAIN, CARBON SEQUESTRATION, AND PORT DECARBONISATION

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Considering the global initiatives to become nature positive by 2030 [1], the United Nations (UN) sustainable development goals [2], and the new biodiversity net gain (BNG) regulations in the UK [3] there has been lots of discussion regarding developing marine net gain (MNG) [4,5]. As our oceans face unprecedented challenges, from climate change to overfishing, the need for effective marine restoration strategies has never been greater [6,7,8]. Here we dive into the fascinating world of marine restoration and explore its potential for MNG, carbon offsetting, and in securing a sustainable future for our oceans and overall planet. We find that the positive impacts of restoration and reviving marine habitats are wide-ranging, from enhancing biodiversity and supporting sustainable fisheries [9], improving water quality [10], to contributing to carbon offsetting efforts [11]. All helping to combat climate change and mitigate its effects on our planet.

The importance of marine restoration

The ocean, covering 71% of the Earth's surface, is home to approximately 80% of all life on the planet [12]. Healthy marine ecosystems are responsible for generating 50% of the oxygen that we breathe as well as absorb 25% of all CO2 emissions [13]. The Ocean and its marine habitats also play a crucial role in regulation the Earth's climate and absorb up to 90% of the additional heat generated from anthropogenic CO2 emissions [13]. Accordingly, marine restoration holds immense importance in safeguarding the health and vitality of our oceans [9]. As human activities continue to take a toll on marine ecosystems [14,15], restoration efforts offer a glimmer of hope. A wide range of methods and techniques are employed in marine restoration projects, depending on the specific ecosystem and the restoration goals. These range from seagrass restoration, mangrove restoration, to coral restoration projects (see Figure 1). By restoring damaged habitats, such as coral reefs, seagrass beds, and mangrove forests, we can create resilient ecosystems that can withstand the impacts of climate change and support a diverse array of marine life [16]. On top of being crucial for marine biodiversity, these restoration efforts can provide shoreline protection [17], carbon sequestration [11,18], and the provision of food and livelihoods for coastal communities. They can also act as a catalyst for positive change. By engaging local communities and stakeholders in marine restoration projects, we can raise awareness about the importance of ocean conservation and foster a sense of stewardship. Overall, through restoring and protecting these marine ecosystems, we can ensure the long-term sustainability of these services, benefitting both the environment and human societies.

Figure 1 *. Images illustrating the different types of marine habitat restoration.*

Case studies of successful marine restoration projects

Numerous marine restoration projects have achieved remarkable success in recent years, showcasing the potential for positive outcomes. The Great Barrier Reef Restoration Project, for example, has employed innovative techniques such as coral larval cloud seeding to enhance coral recovery and promote the growth of new colonies [19]. In the United States, the restoration of the oyster reefs in Chesapeake Bay has not only improved water quality but also provided valuable habitats for countless marine species [20]. This has had a cascading effect on the entire ecosystem, leading to increased biodiversity and enhanced resilience against environmental stressors. Additionally, the restoration of seagrass meadows in the Mediterranean Sea [21] and in the mid-western Atlantic coastal lagoons [22] have demonstrated the potential for carbon offsetting through marine restoration. These projects have not only sequestered significant amounts of carbon but have also provided essential habitats for endangered species. These case studies highlight the success stories that can be achieved through dedicated restoration efforts and offer valuable insights into the strategies and techniques that can be employed in future marine restoration projects.

The potential benefits of Marine Restoration for MNG and Carbon Offsetting

The Science Based Targets for Nature (SBTN) states that "There is no net zero without meaningful action on Nature" [23]. Marine restoration efforts represent significant opportunities for the integration of both marine net gain (MNG) and carbon offsetting to address climate change effectively. MNG is a relatively new concept that is being discussed in the UK that aims to achieve an overall increase in the quantity and quality of marine habitats resulting from development projects [4,5]. Traditionally, development projects have focused on minimising harm to the environment. However, the concept of marine net gain, first introduced in 2022, goes beyond this by actively seeking to enhance marine ecosystems. At present this exciting emerging area of marine policy, which offers the opportunity to accelerate the recovery of marine nature recovery in the UK, is still being discussed [24]. Under the MNG approach, similarly to biodiversity net gain (BNG), developers would be required to deliver measurable improvements to marine habitats to compensate for any loss to marine habitats that may occur due to their projects. This can be achieved through the restoration or creation of new habitats, as well as the implementation of measures to reduce impact and protect vulnerable species. By prioritising MNG, marine development projects can contribute to the conservation and restoration of marine ecosystems, even in areas where habitat loss is unavoidable. This approach not only benefits the environment but also ensures the long-term sustainability of development activities by integrating environmental considerations into their planning and implementation. Simultaneously, marine restoration and MNG efforts represent a significant opportunity for carbon offsetting. This being an approach which allows individuals, organisations, or governments to compensate for their carbon emissions by investing in projects that reduce or remove greenhouse gases from the atmosphere. While mostly associated with land-based activities, such as reforestation and land-based renewable energy projects, marine habitats play a major role in carbon sequestration [11,16]. Healthy marine ecosystems, including mangrove forests, seagrass meadows, coral reefs, and saltmarshes, have the capacity to sequester and store vast amounts of carbon. As such, there has been an exponential increase in marine restoration efforts [9] and marine renewable energy projects [25,26,27], both playing a critical role in carbon offsetting. Marine restoration projects can also indirectly contribute to carbon offsetting by reducing the need for destructive practices that release large amounts of carbon, such as bottom trawling or dredging [28]. By restoring and protecting these marine ecosystems, we can enhance their biodiversity and carbon storage potential. Thus, contribute to global efforts to help mitigate the biodiversity loss crisis [29,30] and well as carbon emissions, and consequently help create a more sustainable future.

Exploring the possibilities of restoring marine habitats within Ports

Due to anthropogenic activities such as fishing and shipping, a wide range of marine habitats have been impacted around ports [31,32,33]. As such, direct engagement with ocean industries that have a significant impact on marine habitats and ecosystems provides an opportunity to alleviate their pressures on the marine environment and adopt sustainable practices, yielding extensive environmental benefits. Accordingly, here we explore the feasibility of restoring and reviving marine habitats within Port locations as these subsea habitats hold significant potential for both biodiversity conservation and carbon offsetting. Targeted restoration efforts should be considered due to the typical impact of fishing and shipping activities on marine ecosystems, including habitat degradation and pollution. By revitalising subsea habitats, such as seagrass meadows (or coral reefs depending on location), we can create essential corridors that support a rich tapestry of marine life. The restored habitats act as natural buffers, enhancing biodiversity by providing shelter, breeding grounds, and feeding areas for a myriad of species (Figure 2). The revitalised ecosystems can also contribute to carbon offsetting, with the potential to sequester substantial amounts of carbon dioxide depending on the species being integrated throughout restoration. It is important to consider the variety of species being integrated throughout habitat restoration, that suit the specified habitat, to maximise the potential for biodiversity gains, ecosystem resilience, and carbon offsetting. Furthermore, habitat restoration efforts often go hand in hand with the removal of invasive species and the implementation of stricter regulations to prevent further degradation such as MNG. These measures help to create a conducive environment for the success of restoration projects and ensure the long-term sustainability of restored ecosystems. By investing in marine restoration projects that incorporate the concepts of MNG and carbon offsetting at Port locations, governments, businesses, and organisations can enhance their social responsibility and demonstrate their commitment to sustainable practices. As ships traverse these rehabilitated areas, they not only will navigate through healthier marine environments, but will also support the creation of marine biodiversity and carbon offsetting credits contributing to global climate goals.

Figure 2. *Conceptual visualisation of a port location with vibrant marine life following successful coral restoration efforts (Adobe Firefly AI Image Generator).*

Challenges and limitations of combined MNG and carbon offsetting projects

While the promotion of MNG and carbon offsetting through marine restoration projects within Ports holds great promise, it does not come without challenges and limitations. One of the main challenges is ensuring the long-term success and sustainability of restoration projects. With a significant hurdle for marine restoration projects being financing, as these projects often require substantial investment [34]. Securing funding from various sources, including government grants, private donations, and corporate partnerships, is crucial for the implementation and continuation of restoration initiatives. Additionally, similarly to BNG in England [3] and the enforced long-term management plan [35], the success of marine restoration projects combining MNG and carbon offsetting, would depend on accurate measurement, monitoring, and long-term condition of the restored habitats. Marine ecosystems are complex and dynamic, and therefore require ongoing monitoring and adaptive management to ensure that restoration, MNG, and carbon offsetting efforts are effective. As such, developing robust methodologies for quantifying the benefits of these efforts is essential for ensuring the credibility and integrity of these approaches.

Accordingly, a collaborative effort involving governments, organisations, and individuals is required. Governments play a crucial role in creating and enforcing regulations that protect marine ecosystems and incentivise restoration efforts. Additionally, they can provide financial support and facilitate partnerships between different stakeholders. Non-governmental organisations (NGOs) and research institutions also play a vital role in advancing the science and practice of marine restoration. By conducting research, raising awareness, and advocating for policy changes, these organisations contribute to the overall success of restoration initiatives. Furthermore, businesses and corporations can make a significant impact by integrating marine restoration, MNG, and carbon offsetting into their strategies. By adopting sustainable practices, investing in restoration projects, and engaging in responsible coastal development, companies can contribute to the preservation of marine ecosystems and help build a more sustainable future.

Conclusion: Harnessing Marine Restoration for a Sustainable Future

Marine restoration holds immense potential for addressing the challenges facing our oceans and mitigating the effects of climate change. The potential of restoring marine habitats underscores a transformative approach toward achieving Marine Net Gain (MNG), enhancing carbon sequestration, and promoting port decarbonisation. The urgent need for marine restoration is evident, given the escalating impacts of human activities on marine ecosystems. The examples of successful projects discussed in the article, from the revitalisation of the Great Barrier Reef to the restoration of oyster reefs in Chesapeake Bay, illuminate the tangible benefits of these endeavours, not only for biodiversity but also for climate mitigation and community livelihoods. Integrating MNG and carbon offsetting into marine development projects, such as Port developments, presents an innovative way to minimise our impact on the marine environment and promote sustainable practices. However, the challenges of financing, long-term sustainability, and effective monitoring must be addressed through robust partnerships among governments, NGOs, businesses, and local communities. By fostering a collaborative and inclusive approach to conserve and enhance marine habitats impacted by development projects and anthropogenic activities, we can secure a healthier future for our oceans and, by extension, our planet.

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