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Title/Heading. Bringing Concrete to Life - Enhancing Natural Processes on Concrete Based Coastal and Marine Infrastructure (CMI)

Context and rationale.

Concrete accounts for about 70% of coastal and marine construction (Sharma., 2009) and provides a poor substrate for marine flora and fauna due to its chemical properties, usually supporting low biodiversity and a high proportion of non-natives (McManus et al., 2017). As many countries are adopting strategies of "Blue Growth", aimed at supporting sustainable management of marine resources in the maritime sectors, interest in integrating environmentally sensitive multi-function solutions to reduce the ecological and carbon footprint of working waterfronts, ports, marinas, and cities is on the rise. However, in order to achieve a significant ecological uplift globally, there is a need for large scale implementation, calling for practical solutions that can be simply and cost-effectively implemented.

An overview of the contribution.

The ecological engineering of shorelines schemes is an evolving discipline (Mitsch., 2012) with the aim of building more inclusive, resilient and safe coastal and marine structures for people and nature that maximize benefits for ecosystems, society and economies (Mayer-Pinto et al., 2017). By integrating environmentally sensitive technologies into the planning, design, and construction of urban, coastal, and marine infrastructure, it is possible to harness natural processes both for ecological enhancement and improved structural performance, thus bridging development and sustainability. Apart from the highly valuable ecological and structural advantages, these methods also provide economic advantages associated with increased stability, longevity, as well as a reduction in maintenance costs.

How the contribution leverages living natural systems as a solution to avert climate change?

Bioenhancing concrete elements can induce the growth of ecosystem engineers (Coleman and Williams, 2002) that have profound impacts on the way communities develop and, ultimately, on biodiversity. Many of these ecosystem engineers have an environmental advantage with respect to climate change mitigation and adaptation. Species such as oysters, tube worms, corals and alike, secrete $CaCo_3$ skeletons onto the substrate; serving multiple benefits. Apart from adding structural complexity and heterogeneity, this "biological crust" serves as an active carbon sink, as carbon is assimilated into skeletons of these organisms in a process called biocalcification (Hily et al., 2013). The potential carbon storage in calcitic skeletons of marine organisms is vast as every 1000 g of $CaCO_3$ store 120 g of Carbon. When applied at large-scales, like in port infrastructure, city waterfronts, or massive coastal defense schemes, this can potentially provide a substantial mitigation tool. The use of byproducts and refuse material within the concrete mix design, such as GGBS (slag), is regularly used within ecological concrete and can additionally reduce the carbon footprint of the concrete.

How might the contribution support both climate, mitigation and adaptation as well as other important co-benefits and social, economic and environmental outcomes in coming years. They may include:

Bio-enhancing concrete elements that are eco-engineered to support rich sessile communities can serve multiple ecological, environmental, operational goals. "Bioprotection" in the form of marine flora and fauna, helping to reduce micro-cracking of the concrete and increase resistance within the intertidal environment. Risinger (2012) has demonstrated that it is possible for oyster growth to significantly increase the flexural strength compared to standard concrete with limited growth. Similar results have been found by the authors (Perkol-Finkel and Sella., 2015, Sella and Perkol-Finkel, 2015, Perkol-Finkel et al., 2018), exploring the capacity of ECOncrete® elements to have improved chloride resistance, and increased strength due to Bioprotection. Bioprotection can translate in the long-run to reduction in structural maintenance, and in elongated structural service life. Both of which have significant monetary terms.

Which countries and organizations are involved in the contribution?

This is a global initiative that is being led by government, port authorities regulatory agencies, environmental activists, and the private sector; including engineers, landscape architects, ecologists and marine biologists.

How have stakeholders (for example local communities, youth and indigenous peoples, where applicable) been consulted in developing the contribution?

It is common practice in the design process for public meetings to be held where the opinions and concerns of all stakeholders can be incorporated into the final project.

Where can the contribution be put into action?

Ecological enhancement of concrete based CMI can be appropriately implemented into all coastal and marine waterfront projects that require an engineered structural solution with a reduced carbon footprint and minimal negative impact on the surrounding environment.

How the contribution will be delivered? How will different stakeholders be engaged in its implementation? What are the potential transformational impacts?

Bioenhancing concrete elements can be easily implemented into any project design with the use of bio-enhancing admixtures and the integration of complex surface designs with the use of molds/mold liners, which can be used at local manufacturing facilities along with local cement and aggregate supplies. The interests of the different stakeholders (project client, designer, end users) can be incorporated into the final design through clear project objectives calling for ecological uplift and the enhancement of the marine environment. Once standard specifications and the supply chain for these bioenhancing elements has been established there is no further impact on the manufacturing and construction processes.

Is this initiative contributing to other Climate Action Summit workstreams (industry transition; energy transition; climate finance and carbon pricing; infrastructure, cities and local action; resilience and adaptation; youth and citizenmobilization; social and political drivers; mitigation strategy)?

Depending upon the support of the local regulatory agencies, the inclusion of bioenhancing elements directly within the infrastructure design can count towards on-site mitigation requirements and can dramatically reduce the financial and/or other mitigation efforts that can often accompany project construction.

How does this contribution build upon examples of experience to date? How does the contribution link with different ongoing initiatives?

Over the past decade, the scientific community has studied, experimented, and published, numerous research projects dealing with the topic of ecological enhancement of coastal infrastructure, greening (or rather "Bluing") the gray, and multi-function structures in the marine space. Nonetheless, most of these are very much at research level, with limited large-scale case studies of urban and commercial applications that have applied principles of eco-engineering in waterfronts. In recent years this technology gap was bridged with high-performance bio-enhancing concrete elements, that significantly enhance the biodiversity, species richness, and live cover, compared to standard "gray" concrete construction elements, without affecting the operational needs of the infrastructure (Perkol-Finkel and Sella., 2015, Sella and Perkol-Finkel, 2015, Perkol-Finkel et al., 2018. Figure 2).

What are the mechanisms for funding (withspecific emphasis on potential for partnerships)?

Funding for the proposed mechanisms would be included as part of the overall project costs, whose funding stream would be project specific and not related to the incorporation of the bioenhancing elements. The use of these elements however could qualify for additional funding sources if available.

What are the means of stewardship, metrics for monitoring?

Monitoring metrics include the biological, ecological and structural performance. Stewardship includes the engagement of local stakeholders and users within projects objectives

What is the communication strategy?

The communication strategy consists of the exchange of data from previously installed and verified pilot and full scale projects. This can be achieved through peer reviewed publications, conference presentations and proceedings, and ultimately through the development of local and international best practices, standard operating procedures, or other means of information exchange deemed effective.

What are the details of proponents (indicating the degree of commitment among the countries and organizations that are named).

All countries that are looking to comply with the Sustainability Development Goals are under sever climate change threat and should be committed to this mechanism.