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# SLAGREEF, slag based artificial reefs design preliminary results

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***Abstract* – Climate change exerts a profound impact on coastal regions, with severe environmental consequences. Coastal areas bear the brunt of intense storms that adversely affect both beaches and urban infrastructures situated along the coastlines, resulting in substantial harm to marine ecosystems. Furthermore, proximate urban areas contribute to the contamination of seawater, leading to significant adverse effects on marine life. Conversely, industries such as steel and aggregates generate substantial quantities of slag furnace and inert waste residues, respectively. Although there is often some utilization of these by-products, a considerable volume ultimately finds its way into landfills or serves as backfill. Consequently, the global challenge lies in effectively repurposing these waste residues. This abstract presents a preliminary slag based artificial reefs (AR) design focused on the exploration and advancement of novel materials derived from slag furnace residues and inert waste from. The construction employed a 3D slag-concrete printer to craft artificial reefs. First design is being tested since summer 2023 at Obsea underwater observatory, where a dedicated 24/7 monitoring system was designed and deployed to study how the artificial reef serves a dual purpose by safeguarding coastal areas and contributing to the restoration of damaged ecosystems.**

***Keywords* -** *Recycling, construction technologies, 3D printing, metallurgical slag, mining slag, artificial reef, underwater monitoring, underwater life, Artificial Intelligence (AI) and image processing.*

## I. INTRODUCTION

In recent years, the popularity of artificial reefs (AR) has surged, driven by the aim to increase marine biodiversity and advocate for sustainable fishing practices. These structures, crafted by human intervention, are specifically formulated to replicate the natural habitats of marine organisms. Composed predominantly of materials like concrete, steel, or stone, these artificial reefs are strategically positioned in locations characterized by a dearth of marine life or ecological impairment. The primary objective of deploying artificial reefs is to establish novel habitats capable of sustaining a varied spectrum of marine species, thereby fostering the principles of sustainable fishing practices [1]. The first prototype design was based on Carral's et al. analysis [2], where a list of requirements were introduced as listed in table 1:

| Nr | Requirement | Observation | Nr | Requirement | Observation |
|---|---|---|---|---|---|
| 1 | Concrete printed design | Presentation | 18 | Reef not harmful to fauna and flora | Safety |
| 2 | Modular | Presentation | 19 | Reef not harmful to sea water | Safety |
| 3 | Adaptable to the environment | Presentation | 20 | Pieces must be transportable by any vehicle | Distribution |
| 4 | 1-meter diameter | Presentation | 21 | Design must be concrete printed | Production |
| 5 | Environmentally safe | Presentation | 22 | Design production as easy as possible | Production |
| 6 | Reef's lifetime as long as possible | Dimensions | 23 | Components' production must be sustainable as much as possible | Production |
| 7 | Pieces must be able to gather | Dimensions | 24 | Design production leaves as little waste as possible | Production |
| 8 | Outstanding design | Dimensions | 25 | Product in modular parts | Design |
| 9 | Entire reef design won't exceed one meter in diameter | Dimensions | 26 | Design must be adaptable to the environment | Design |
| 10 | One piece max height of 30cm | Dimensions | 27 | Holes created to allow fishes to live | Design |
| 11 | One piece must be liftable by a human | Dimensions | 28 | Holes created to let current flow through the reef | Design |
| 12 | Reef material is concrete | Material | 29 | Different pieces should be easy to assemble | Ergonomics |
| 13 | Material unaffected by sea water | Material | 30 | Different pieces easily transportable | Ergonomics |
| 14 | Material in contact with water must not rust | Material | 31 | Reef will stand on the sand | Environment |
| 15 | Material won't break under water pressure | Material | 32 | Reef located in a protected environment | Environment |
| 16 | Material shouldn't move due to water velocity | Material | 33 | Product must be constructed (from stored position) in less than 30 minutes | Mechanical |
| 17 | Material pH close to 8.3 | Material | | | |

Table 1. Initial requirements for the design of the modular artificial reef.

## II. DESIGN and DEPLOYMENT

Based on the requirements depicted on table 1, a first design was 3D printed at UPC CATMech facilities in Terrassa and deployed in the seafloor at Obsea cabled observatory in Vilanova i la Geltrú in summer 2023. Since the deployment, the artificial reef has been continuously monitored in order to study how it is being populated by flora and fauna. Figure 1 shows the reef design and the manufactured result once installed underwater. A specific monitoring system was designed and deployed in order to monitor 24/7 how the reef interact with the environment. Thanks to this video monitoring system, a real-time, AI-based analysis software is able to identify macrofaunal as shown in figure 1.

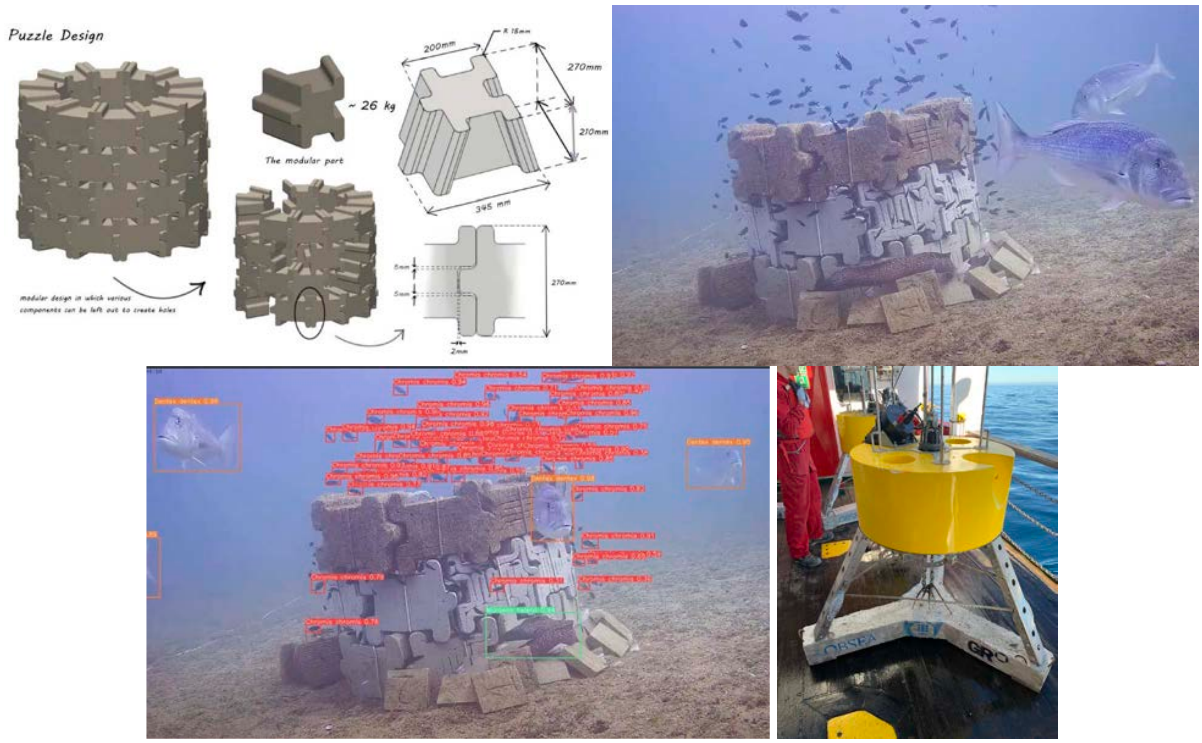


Fig 1.**A)** design of the modular artificial reef. **B)** Artificial reef deployed and monitored at Obsea Observatory. **C)** Real-time, AI-based monitoring results showing the location and species. **D)** Video camera-based monitoring system.

## III. CONCLUSIONS

During the next months, AR will be monitored in order to generate conclusions about its design. Next phase will focus on the design of a 2nd prototype to increase waterflow trough the AR allowing water and small fish passing through it.

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## REFERENCES

[1] J. S. Lima, J. Atalah, P. Sanchez-Jerez, and I. R. Zalmon, “Evaluating the performance and management of artificial reefs using artificial reef multimetric index (ARMI),” *Ocean Coast. Manag.*, vol. 198, Dec. 2020.

[2] L. Carral, M. I. Lamas, J. J. C. Barros, I. López, and R. Carballo, “Proposed Conceptual Framework to Design Artificial Reefs Based on Particular Ecosystem Ecology Traits,” *Biology (Basel).*, vol. 11, no. 5, May 2022.