Title: **Nature-based reef solution for coastal protection and marine biodiversity enhancement (LIFE NatuReef)** (SSD BIO/01 BIO/07)

Research project:
The present research project entitled "**Assessment and monitoring of marine communities to enforce Nature-based reef solution for coastal protection**" belongs to the project LIFE NatuReef (Nature-based reef solution for coastal protection and marine biodiversity enhancement)
Topic: LIFE-2022-SAP-NAT-NATURE
Type of Action: LIFE-PJG
Project n. 101113742

LIFE NatuReef (Nature-based reef solution for coastal protection and marine biodiversity enhancement) aims to apply at a demonstration level the best practices available to the restoration of native oyster and sabellariid reefs, seeding the native species in a rare non-urbanized coastal stretches of the northern Adriatic coasts: the Bevano river mouth (Ravenna municipality, Emilia-Romagna Region, Italy), which is a SCI, SAC and SPA under the EU Natura 2000 (IT4070009 - Ortazzo, Ortazzino, Foce del Torrente Bevano). *Ostrea edulis* and *Sabellaria spinulosa* are native ecosystem engineers able to create three-dimensional reefs that retain sediments and dissipate wave energy, counteracting coastal erosion, which is particularly intense here, and creating ecological niches allowing for high biodiversity and nursery habitats. Native oysters have almost disappeared, and sabellariid reefs are rare in the Mediterranean Sea, representing marginal habitats having lost most of their ecosystem functions at the regional level.
The restored reefs will enhance marine biodiversity providing habitat and feeding ground for priority and non-priority threatened species, like sea turtles, seahorses, and seabirds. They will defend priority and non-priority habitats like beach dunes, coastal lagoons, and pinewood from coastal erosion and salt intrusion, host endangered vegetation, and provide nursery areas to priority bird species.
These reefs will provide several ecosystem goods and services: biodiversity enhancement, improved water quality and clarity, increased fish and shellfish production, sediment stabilisation, and wave energy dissipation, prevent coastal erosion, and a high cultural value. Being living structures, they have the potential to adapt and, to some extent, counteract the effects of climate change, like sea level rise and increased storm and flooding event frequency and intensity, contributing to the resistance and resilience of the coastal marine ecosystem.

Activity plan:

The candidate will work within the Algal Biology research group (AlgoLab) and the Ecology and Conservation of Acquatic, Coastal and Marine environments (CoastEcol) research group of the Department of Biological, Geological and Environmental Sciences (BiGeA), in Ravenna campus, under the supervision of Dr. Laura Pezzolesi and Prof. Federica Costantini.

Biogenic reefs have an inestimable value for the biodiversity they host and for the countless ecosystem goods and services they provide, which are only partially quantifiable in their economic values. As for the time required for their formation, their destruction can often be considered almost irreversible, so bioconstructions require the utmost attention in any conservation measure. Indeed,

tropical, and temperate biogenic reefs are increasingly threatened by multiple stressors resulting in the decline of reef communities worldwide. Natural and anthropogenic stressors include the decline in water quality, overexploitation of resources, habitat destruction, and global climate change among others, which have all been linked in tropical and temperate areas with the occurrence of mass coral bleaching and a variety of diseases and mass mortality events.

In temperate coastal environments, like the Mediterranean Sea and northern Europe, this role is fulfilled by seagrass meadows, oyster, and sabellariid (honeycomb worms) reefs providing a "living shoreline". These ecosystem engineers create three-dimensional structures that retain sediments, dissipate wave energy, and create many ecological niches that allow for high biodiversity and provide nursery habitats. Nowadays, the native European oyster is very rare, especially in the Mediterranean Sea. According to palaeoecological evidence, extensive shell beds formed by large-sized *Arca noae* and *Ostrea edulis* bivalves were present in the northern Adriatic Sea until the early 20th century, when it fell victim to multiple anthropogenic impacts, mainly bottom trawling, and they were replaced by an infauna-dominated community indicative of instability, disturbance, and organic enrichment. Local northern Adriatic fishers still collect young European flat oysters from offshore natural banks to refurbish oyster farms. In the wild, the vertical range of Pacific oysters in the Adriatic Sea is mostly contained in the tidal zone, while the native flat oysters are present exclusively in the subtidal.

The LIFE NatuReef project idea is to apply, at a demonstration level, the best practices available to the restoration of natural oyster and sabellariid reefs, as a nature-based solution for coastal defence and marine biodiversity enrichment, by deploying suitable substrates and seeding the native species in the marine area in front of the mouth of the Bevano river. Although the restoration of oyster and sabellariid worm reefs will be realized at sea, building up biogenic barrier reefs within 200 m off the coast, its protective effects against erosion processes, saline intrusion, and flooding events will extend to the corresponding shore and nearby habitats of the Bevano river mouth. Therefore, the project LIFE NatuReef other than restoring historically lost habitats, will largely contribute to protecting and enhancing a relevant subset of the priority and non-priority habitat types already included in this Natura 2000 site. Bioconstruction, sedimentation, and coastal erosion processes and biodiversity in the intervention area will be monitored throughout the project and beyond. Public engagement actions will involve citizens, bathers, fishermen, and other stakeholders, raising their awareness and improving biodiversity monitoring.

One primary aim of the Candidate's project is to provide the necessary habitat and biodiversity baseline (the condition of the area prior to the activity taking place) at the Bevano river mouth to allow the proper design and implementation of the "basal limestone reef" and the biogenic reefs. This baseline will also provide the reference condition for the subsequent habitat and biodiversity monitoring, necessary to evaluate the achievement of the project objectives in terms of habitat and species conservation, and biodiversity reef restoration. It is important to characterize a range of relevant abiotic parameters (e.g., depth, seabed substrate type, salinity), and biological aspects like the presence of invasive species and pests at the proposed location. It is also essential to establish the presence, distribution, and abundance of existing native and non-native oyster populations as this will inform project planning and will influence the strategy to source oysters. Having good baseline qualitative and quantitative data also provides the benchmark against which future changes can be measured and project successes or failures can be identified. The subsequent monitoring will also help ensure that actions are carried out at the right times and in the right places.

The data needed for properly designing the "basal limestone reef" and the biogenic reefs will be acquired in strict collaboration with the engineers, geologists, and biologists in charge, and transferred to the respective teams as soon as available. The Candidate will use integrative approaches based on morphological identification and eDNA metabarcoding to evaluate community structure. Specifically, sediment and water samples will be collected and these eDNA samples will be analysed using a multi-marker approach to characterize all the eukaryotic and prokaryotic communities (e.g., COI for most metazoans, 18S rDNA for non-metazoans, 16S for bacterial communities). For each selected marker, a sequencing library will be prepared and after purification, the library will be sequenced using a MinION Mk1C sequencing platform. The Oxford Nanopore MinION will allow the generation of low-cost and low-time sequence data in the field. As filter-feeding benthic species rely on plankton production, qualitative and quantitative analysis of phytoplankton communities will help understand resource availability across the food web. These data will be used as a baseline to monitor the efficiency of the intervention in not losing or increasing biodiversity in the surrounding sedimentary soft bottom habitat and will be integrated in marine habitat mapping in collaborations with the geological group.

Another aim is to assure biosecurity from different points of view. Disease from some pathogens is a major threat to native oysters both in aquaculture and in the wild. In particular, the haplosporidian species *Bonamia ostreae*, which causes the disease bonamiosis, is still expanding its range in Europe and can cause up to 90% mortality when it arrives in a population. Similarly, invasive non-native species (NIS) are considered a key threat to biodiversity throughout European waters.
Harmful algal blooms of species able to produce biotoxins could also affect biodiversity and biosecurity. Vectors include shipping and recreational boating, but a major cause has been shellfish movements. The presence or introduction of a disease or NIS species may negatively impact the conservation objectives for protected species and habitats. They also pose a threat to the success of native oyster restoration through competition for food and space, predation, outbreaks of diseases, negatively impacting the biodiversity associated with healthy biogenic habitat, and reputational damage. Another relevant aspect of biosecurity is to maintain and verify a high genetic diversity in the seeded populations, which should be achieved by using local wild specimens in the seeding practices and by good connectivity with other natural populations.
Biosecurity will be considered an integrated part of restoration practice through the project and will be addressed by the adoption of a specific biosecurity measures plan, fully compliant with the European guidelines on biosecurity in native oyster restoration. This plan will go far beyond the legislative obligations and will include the code of practice to prevent any biological risks and means of verification, including genetic analyses.
The BMP will consider three main aspects:
1. preventing and monitoring oyster diseases;
2. preventing and monitoring non-indigenous species invasion;
3. ensuring and monitoring oyster and sabellariid polychaetes population genetic diversity and connectivity to other populations.
The candidate will perform a genomic characterization of the deployed oysters (*Ostrea edulis*) and of the *Sabellaria* individuals from the populations used for the transplant. Depending on the source oyster populations, 20-30 individuals will be sampled for genetic analysis. Sequence polymorphism of mitochondrial markers and the RADseq library will be performed. Populations with higher genetic diversity will be selected for transplant to increase population resilience, avoid inbreeding, and ensure

its long-term adaptability (e.g., changing environment). To monitor the changes in genetic diversity of the restored populations and the parentage relationships among individuals every year, several recruits will be sampled (according to the total number of recruits to not hurt the restoration) and will be analysed with the same markers and SNPs used before.

The project will consist of:

- Literature review on the use of integrative approaches in the Nature-based reef solution implementation
- Analyses of the marine biodiversity in biogenic reefs;
- Biosecurity assessment of the species selected for the creation of the Nature-based reef solution;
- Activities of dissemination and communication related to the project
- Final report

Required Skills:

Applicants should:

- Proven expertise in molecular methods (e.g., next generation sequencing), and characterization of algal and animal communities with an integrated morphological and molecular approach
- Proven experience in the field of microalgal cultivation, analysis of toxic or harmful microalgae, monoalgal culture preparation
- Proven experience in the characterization of the bacterial community, isolation, and characterization of bacteria
- Proven experience in bioinformatic data analysis
- Proven experience in writing scientific reports or articles
- Good knowledge of spoken and written English