MS9: Implementation of field actions to enhance effectiveness of restoration protocols

Marine Ecosystem Restoration in Changing European Seas MERCES

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Brief description

Milestone MS9 provides a synthesis of field actions that defines effective protocols for the restoration of macroalgal forests and coralligenous habitats in locations where it was previously present.
The document is divided considering the two main habitats targeted in WP3: shallow hard bottoms (0 to 25 m depth) dominated by macroalgal species and kelp, and the shallow and mesophotic coralligenous habitats with macroinvertebrate species (gorgonians, sponges, bryozoans).
During the workshop held in Barcelona (19-20 January 2017 – 2-5 May 2017) the core list of targeted species for restoration activities in WP3 was defined and field activities and experimental locations discussed among partners. Starting from the information reported in the final report (i.e. Deliverable 3.1. "State of knowledge on key eco-evolutionary processes and factors driving the resilience of the shallow hard bottoms and mesophotic habitats") different restoration actions have been decided and will be carried out in different areas and habitats to explore the feasibility of restoration for the target species. All undertaken activities have just recently started. The results are not yet available, hence in this document we describe the first field implementation across locations and habitats. We expect to evaluate the effectiveness of restoration setups by the end of 2017. The conclusions of these actions plus the results from Task 3.2. "Test the effectiveness of restoration actions under a changing ocean scenario" will allow to define the restoration protocols to be used for rocky coastal habitats targeted in MERCES project (see also Milestone 10 for further details).

<u>Shallow hard bottoms (0 to 25 m depth)</u>
In this habitat, field actions related to effective restoration procedures for macroalgae will involve 1- transplants of juvenile and adult individuals 2- assessment of the effects of herbivores

Restoration activities will be carried out on macroalgal species (mainly *Cystoseira* spp.) and two kelp species (*Laminaria hyperborea* and *Saccharina latissima*), as well as key species associated to these habitats, such as herbivore sea-urchins, decapodes and various fish species. The activities will be conducted in four Mediterranean countries: Spain, Italy, Turkey, and Norway. Even though different species will be used across locations, comparability of the processes we are testing will be guaranteed by the use of similar methodologies and hypotheses (see also MS10).

1- Transplanting of juvenile and adult individuals of macroalgae
Transplanting of adult individuals of *Cystoseira*, *Laminaria hyperborea* and *Saccharina latissima* is currently carried out in different habitats (fringe, subtidal) and areas (Spain, Italy, Norway). In addition, a key issue in WP3 is the implementation of nurseries of *Cystoseira* that will provide sporeling cultures for the transplant of juveniles by the use of plates. This activity is carried out in Blanes (CSIC) and Trieste/Lecce (CoNISMa) to compare methodologies and outcomes. Primary branches of fertile thalli of different species of *Cystoseira* are collected, refrigerated in seawater, and brought to the laboratory for sporeling cultures. A protocol to fertilize and cultivate *Cystoseira* spp. embrios in aquaria, enabling the production of large numbers of germlings from few fertile apexes is under preparation. This technique allows reintroducing *Cystoseira* spp. on a vast extent, with little impact on existing canopies. Based on gathered information

about the techniques developed for each species, we expect that germlings on the settlement plates will reach suitable dimensions (i.e. approximately 1 cm) for transplanting to restoration sites. Juveniles will be transplanted with and without the presence of adults to assess the effects of the adult canopy. All steps we are following in the lab and in the field will be compared across groups to provide the most successful protocols describing all steps of restoration activities.

2- Assessment of the effects of herbivores

The separate and combined effect of adult canopy of macroalgae and kelp and herbivore density on the survival and growth of juveniles cultured in aquaria and transplanted to the field will be carried out in different habitats (fringe, subtidal) and areas (Spain, Italy) (Fig. 1 for an example of experimental design carried out in Apulia). Several species of herbivores (sea urchins, sea snails, limpets and the fish *Sarpa salpa*) have shown to be abundant in areas where *C. amentacea* and kelp are declining (our observation) and are known to drastically reduce the survival of juveniles. As a consequence, different approaches will be used (removal/cages) to limit their impact.

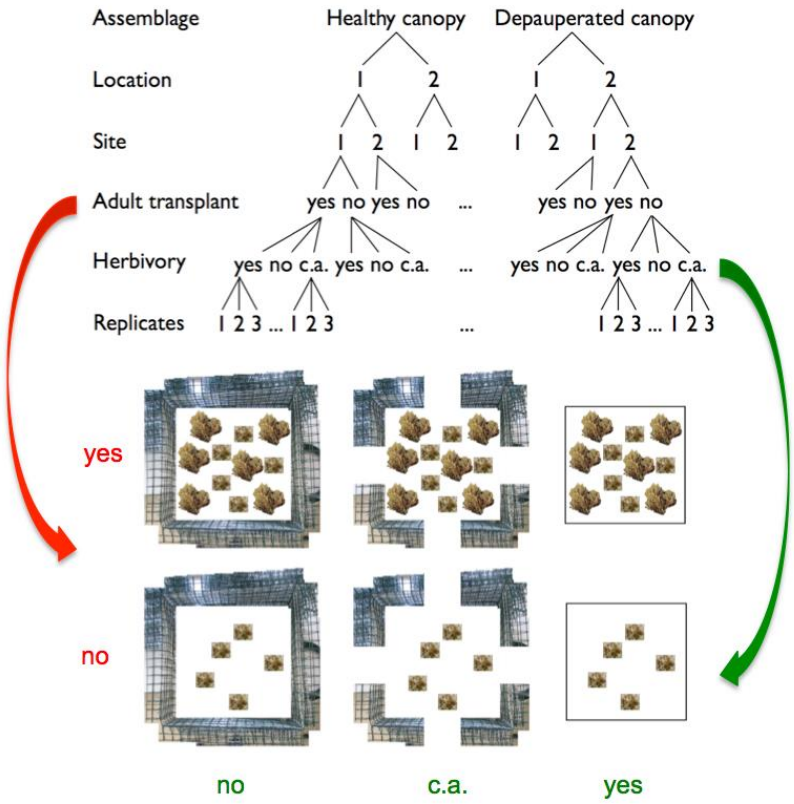

Figure 1. Schematic representation of the experimental design carried out in one of the locations in the fringe (Porto Cesareo, Apulia, Italy).

<u>Shallow and mesophotic coralligenous habitats</u>

In coralligenous habitats restoration activities are being conducted in 6 localities: encompassing three different Mediterranean countries Spain, Italy and Croatia (Gallinara Island, Portofino Promontory in Italy, Medes Islands and Cap de Creus in Spain and Sokol and Mai Obrucan in Croatia). Two additional locations, Gokova in Turkey might be also included during 2017 summer expanding to 4 countries the size of the experiment. Scandola in France could be included depending on the potential of

local facilities to include this location in one of the two transregional experiments planned within WP3.
The activities will address a total of 12 species belonging to three main taxonomic groups Cnidaria/Anthozoa, Porifera/Demospongiae and Bryozoa. Two of these groups Cnidaria/Anthozoa, and Bryozoa are common to all main geographic areas while Porifera/Demospongiae are shared between two countries (Italy-Ligurian Sea and Croatia -Adriatic Sea). The exception is the location in Turkey for which coralligenous habitats are dwelling in deep waters and field work is limited.
The main restoration actions conducted in coralligenous are transplants. Different methods are being used (see MS10) depending on the species. During the WP3 training session in Medes Islands the transplant methods were shared ensuring that similar approaches and materials are used across the localities. The red gorgonian *Paramuricea clavata* is the one used in most areas and the one used for the pilot action in the Medes Islands in collaboration with 14 instructors from local diving centers which allowed transplant of more than 400 gorgonians covering an area of about 10 m^2. However, all the selected gorgonian species share similar morphology and the same methodology can therefor be applied successfully across different species.
The transplants on Porifera/Demospongiae are more difficult to apply. However, the method developed by the GAIA/UNIVPM team (MS10 and applied during the training workshop and demonstrated its feasibility and the undergoing tests on sponge transplants are already set in Italy and Spain.
Finally, recruitment enhancement techniques for bryozoans (MS10) will be used in Italy, Croatia and Spain although tests on transplants methods were also carried out in Spain.

It is also noteworthy that two transregional experiments encompassing Spain, Italy and Croatia will be conducted within WP3. The first is a facilitation experiment aiming to test if arborescent species can affect the survival and growth of co-occurring encrusting and massive organisms and has been designed using the red gorgonian *Paramuricea clavata* and the bryozoan *Pentapora fascialis* as model species. The experiment will be replicated in Spain, Italy and Croatia and is based on the comparison between series of 0,25 m^2 experimental plots. Four experimental plots controls (no gorgonians and no bryozoans) and bryozoans with and without gorgonian colonies for a total of 4 replicates per treatment will be considered. The hypothesis is that the arborescent layer (15 *Paramuricea clavata* fragments up to 20 cm in maximal height per experimental plot) could facilitate the settlement, growth and survival of bryozoan colonies settled on a plastic grid placed in the experimental plots (Fig. 2 and 3).

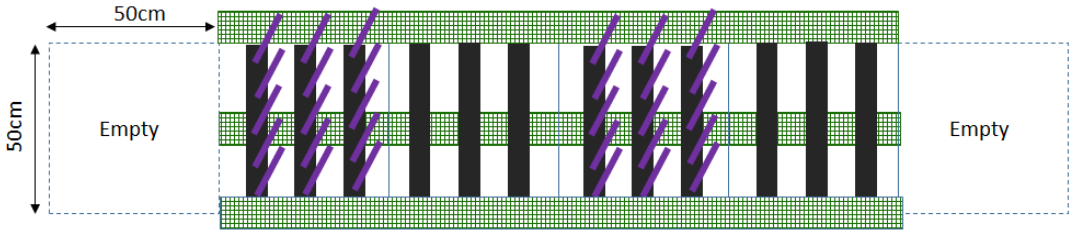

Fig. 2. Experimental plots for the facilitation experiment.

Fig. 3. Experiment for testing the effect of *Paramuricea* on bryozoans in the field.

The second experiment will experimentally test the thermal resistance of red gorgonian *Paramuricea clavata* populations from several locations in Spain, Italy and Croatia and potentially one in France (depending on the logistics arrangements). To this end we will combine transregional common garden thermotolerance experiments in aquaria and population genomics analyses to disentangle the processes driving the population responses to thermal stress in the temperate habitat forming coral *Paramuricea clavata*. With this experiment, we will address two main objectives: i) to characterize the patterns of differential responses in *Paramuricea clavata*; ii) to explore the molecular basis of the differential responses. This experiment is one of the largest common garden experiments planned to date in the marine realm.

The current restoration activities in coralligenous are considered a good test for the robustness and effectiveness of restoration protocols since similar methods are applied by different teames and under different environmental conditions. Despite coralligenous habitats develop in dim-light habitats in moderate current conditions, these habitats display a high degree of heterogeneity in their configurations depending on environmental conditions. Therefore, the expected results will be a step forward for the generalization and refining the proposed protocols for restoration actions in the coralligenous which could not have been obtained otherwise.