MS10:

Title: Evaluation of efficiency of restoration setups (devices, materials etc..) in shallow hard bottoms and mesophotic habitats

Marine Ecosystem Restoration in Changing European Seas MERCES

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Means of verification

Brief description

Within WP3 we have applied different restoration setups in order to evaluate their efficiency and potential for scaling up restoration actions.
In this document we divided the tests carried out accordingly to two main habitats targeted in WP3.
1) shallow hard bottoms (0 to 25 m depth) dominated by 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.
2) shallow and mesophotic coralligenous habitats restoration actions are targeting macroinvertebrate species (mainly gorgonians and sponges but also bryozoans)

See Annex 1 for model species for restoration actions.

All activities undertaken are still ongoing and some have just started recently. Hence, the final results are not yet available and the present document only includes the description of setups. We expect to evaluate the effectiveness of restoration setups by the end of 2017. The conclusions will allow the definition of the restoration protocols to be used for rocky coastal habitats targeted in the MERCES project.

<u>Shallow hard bottoms</u>
Three main approaches are being tested:
(i) Macroalgal transplants
(ii) Recruitment enhancement
(iii) Removal actions

(i) After identifying proper donor *Cystoseira* populations, transplants of different *Cystoseira* spp. are being conducted in different areas and habitats. Two methods are tested; in some species we could take advantage of the fact that some species grow over small boulders the size of which allows their transport to restoration sites. However, in general, algae are carefully detached from the donor area maintaining a small portion of the original substrate detached from the rock with a hammer and chisel. These individuals are then directly glued to the rock with two component epoxy putty.
Based on differences in morphology, growth forms and vulnerability to sea urchin grazing, different transplant techniques are applied for the two different kelp species *L. hyperborea* and *S. latissima* in Norway. Removal of the two species are done by carefully detaching the holdfast of the kelp from the substratum at the donor sites.
At the restoration site *L. hyperborea* are attached to chains stretched along the rocky seabed. The chains are sufficiently heavy, so that they avoid drag and lie firmly on the seabed. Plastic cable ties are passed over the stipe and kelp holdfast, securing the plants to the chains. A small float is attached around the uppermost part of the stipe to ensure an upright position of the plant.
S. latissima, which has a short and flexible stipe and a long lamina, are mounted on vertical ropes and suspended in the water column. The plants are attached to the rope by inserting the kelp holdfast in between the strands of the rope. The ropes are anchored to chains at the sea floor in one end and attached to a float in the other end (Figure 1).

Figure 1. Transplantation of *L. hyperborea* (photo NIVA)

(ii) For recruitment enhancement *in situ* and *ex situ* culture techniques are being developed for different *Cystoseira* spp. species and for different habitats. *In situ* techniques consist in providing artificial and natural substrates, to increase the limited natural recruitment. We tested *in situ* the capacity of natural populations to harbor new recruits, their dispersion capability and their survival. The suitability and success of different substrate nature are also tested.
In the laboratory, similar techniques were applied in controlled temperature conditions to determine the tolerance range of those variables and to avoid the high mortality experienced during the first development stages of the juveniles. For different areas and populations, in the laboratory, mature receptacles of *Cystoseira* will be collected for fertilization and germling cultivation in aquaria. Juveniles are being transplanted on settlement plates and fixed with epoxy putty *in situ*.
The final goal is to obtain new individuals susceptible to be transported (with the settlement substrata) and for transplantation to the restoration targeted areas. The monitoring of settled individuals as well as the donor populations is being conducted to study their survival, growth, phenology and to assess the recruitment rate in restored populations, which will ultimately determine the success of restoration actions.

Figure 2. *Ex situ* recruitment enhancement experiments for restoration of *Cystoseira* spp. (Photo CSIC-UdG)

Likewise recruitment enhancement with the sponge *Chondrilla nucula* is being conducted. Long- and newly-established plots of transplanted *C. nucula* are being monitored along with the surrounding community on artificial substrata (concrete blocks). This work is not exploring transplantation techniques (which have already proved effective). Rather, it aims to shed light on the possible role of the sponge in enhancing recruitment of benthic species. Moreover, the newly-established plots aim to clarify aspects of the life history strategy of *C. nucula*.

(iii) Removal actions / Caging

Different experimental designs are being applied to test the effect of limiting the impact of herbivores and thereby enhancing the restoration potential of macroalgal habitats. In general, these experiments are using approaches to avoid herbivory by setting cages and through the removal of sea urchins. However, in some areas, caging will also be used to prevent herbivory on adults and juveniles as well as to increase recruitment.

Shallow and mesophotic coralligenous habitats

Two main approaches are being tested
(i) Macroinvertebrate transplants
(ii) Recruitment enhancement

(i) For the targeted macroinvertebrate species we used different approaches depending on the model species.
For gorgonians either apical fragments or entire colonies are directly glued to the substrate using two-component epoxy putty. We are testing the use of two different types of epoxy putty and the potential effect of fragment size on the survival of transplants.

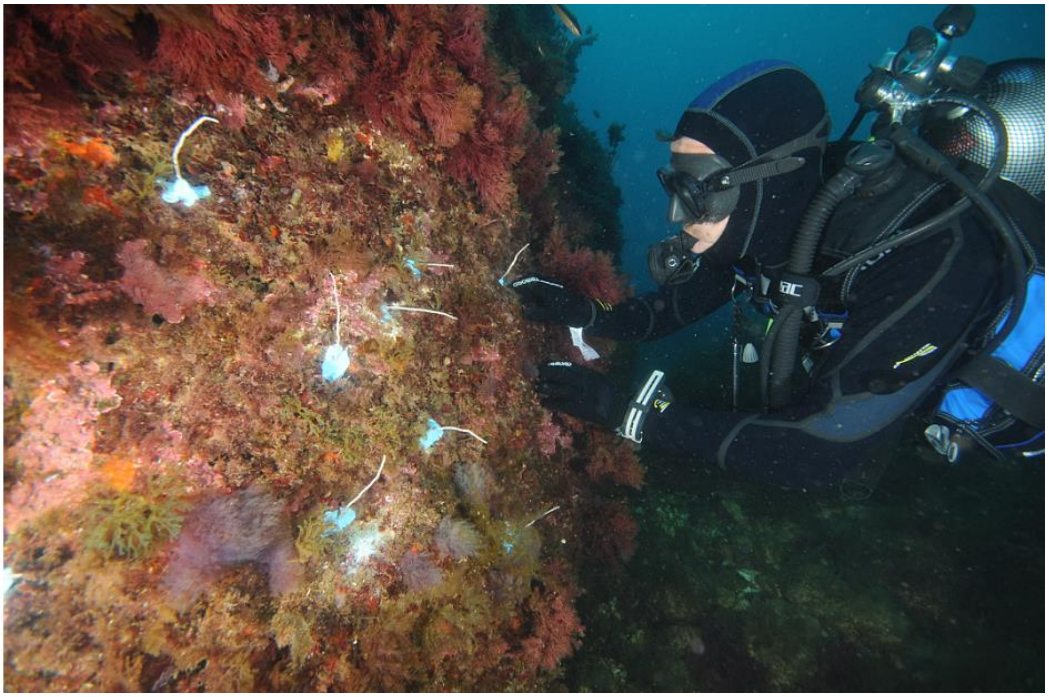

Figure 3. *In situ* test of different epoxy putty for the transplants of gorgonian species (Photo CSIC).

For sponges with a highly structured skeleton resulting in a "hard" body (e.g. *Petrosia ficiformis*), they can be easily cut to generate transplants with quite rough surfaces. However, other species with a structured skeleton have a more "rubber-like" texture, such as *Spongia officinalis* and *S. lamella*. These require more manipulation to be cut into transplants and such transplants are less amenable to be directly glued to the substrate given their smooth surfaces. In this case, plastic dowels are inserted in the transplants, providing better hold when glued to the substratum with the putty. The use of plastic dowels has been also tested in "hard" body sponges to test the efficiency of both approaches

For the two bryozoan species we carried out adult transplants of colony fragments of two species, *Myriapora truncata* and *Pentapora fascialis* , directly glued to the substrate using two-component epoxy putty. The preliminary results revealed that the survival of transplanted *M. truncata* colonies were higher than *P. fascialis* ones, which showed to be highly sensitive to manipulation.

(ii) Recruitment enhancement
For the two bryozoan species different types of recruitment substrates are being tested. The preliminary results showed different preferences between species, with three dimensional

structures for *P. fascialis*, and plain-surface settlement plates for *M. truncata* being more effective. In addition plastic mesh has been fixed to the substrate with plastic screws and flanges in the coralligenous to test its potential use as recruitment surface for bryozoans, facilitating their transport and installation to damaged populations given the fragility of some species such as *P. facialis*. Finally, in some experiments cages will also be used to protect the transplants or existing individuals against damage caused especially by illegal fishing.

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Annex 1

WP3 Model species for restoration actions

In the macroalgal habitats, the restoration actions will be focused on erect macroalgae belonging to the genus *Cystoseira spp*. In particular, transplanting experiments on adults and juveniles will be carried out on the species *Cystoseira balearica*, *C. amentacea*, *C. barbata*, *C. crinita*, *C. zosteroides* as well as the kelp species *Laminaria hyperborea* and *Saccharina latissimi* (Norway). Transplant experiments will be carried out on adult and juvenile individuals of the species *Cystoseira balearica*, *C. amentacea*, *C. barbata*, *C. crinita*, *C. zosteroides* and the kelp species *L. hyperborea*, *S. latissima*. Cage experiments will be used with the fish *Siganus luridus*. The removal of the sea urchins *Paracentrotus lividus*, *Arbacia lixula* and *Strongylocentrotus droebachiensis* will be used in some sites to further facilitate the recovery of disturbed assemblages. Caging experiments will be used with the fish *Siganus luridus* on macroalgae on overgrazed areas of Foça and Gökova Bay, Turkey. The removal of the sea urchins *Paracentrotus lividus* and *Arbacia lixula* will be also used in some sites to further facilitate the recovery of disturbed assemblages. Recruitment enhancement work is done on the sponge *Chondrilla nucula*.

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In shallow and mesophotic coralligenous habitats, restoration actions are focused on different habitat forming species including three main taxonomic groups Cnidaria/Anthozoa (*Paramuricea clavata*, *Corallium rubrum* and *Eunicella* spp.), Porifera/Demospongiae (*Aplysina* spp., *Spongia* spp., *Petrosia ficiformis*) and Bryozoa (*Pentapora fascialis*; *Myriapora truncata*).