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BIODEGRADABLE ANCHOR MODULAR SYSTEM FOR TRANSPLANTING *POSIDONIA OCEANICA* CUTTINGS

Abstract
Seagrass vegetative transplanting methods involve fixing to the seabed by anchoring the vegetative shoots. Several seagrass restoration projects have been attempted using this method, and most of transplants mortality, particularly in high water motion environments, is precisely attributable to dislodgement. For this purpose, a new and innovative Posidonia oceanica (Alismatales, Tracheophyta) transplant system, composed of an artificial underwater support constructed of starch-based biodegradable materials (Mater-Bi), was developed. To evaluate the efficacy of this system, in May 2012 a P. oceanica transplant was implemented in an area of high environmental quality (Mondello Bay, Palermo - Italy). In particular, after twenty months from transplanting cuttings survival was 94% and shoot density per unit showed a slight increment than the starting one. These results can be particularly important when large scale transplanting projects are carried out because this anchor system increases success probability and reduces costs.

Key-words: *Posidonia oceanica*, biodegradable support, Sicily, seagrass transplanting.

Introduction
Seagrass meadows are the most widespread and productive coastal ecosystems worldwide and provide a high-value ecosystem service (Vassallo *et al*., 2013). Recently, a seagrass decline rate of 2-5% yr^{-1} was globally estimated (Waycott *et al.,* 2009); in particular, for the Mediterranean basin, *Posidonia oceanica* areal extent appears to be lost (between 13% and 50%), with a decrease of shoot density of remaining meadows by 50% for the last 20 years (Marbà *et al.*, 2014). Thus, recovery planning are required to arrest and reverse the decline of this species. For mitigating the continuous loss of this seagrass habitat, restorations through transplanting projects have been suggested (Duarte *et al.*, 2013). Since the 1970s, reforestations with *P. oceanica* have been carried out to assess various transplanting techniques and most of the failures of *P. oceanica* transplants (80%) has been ascribed to anchor system (Park & Lee, 2010). Here we show a new innovative technique developed for the restoration of *P. oceanica* meadows based on the use of an underwater anchor modular system constructed of starch-based biodegradable materials (Mater-Bi), in order to: i) speed up the natural growth and colonization of an area by the plant, ii) increase transplant success probability limiting costs, and iii) reduce the impact on marine environment.

Materials and methods
Study area is located in the Mondello Bay (Palermo, Sicily, Italy). The seabed is characterized by sand, colonized by a *P. oceanica* meadow and *Cymodocea nodosa*, and *P. oceanica* dead *matte* (Calvo *et al*., 1993). In order to evaluate the feasibility of a newly

transplanting technique, in May 2012 *P. oceanica* shoots have been transplanted by using an innovative product (patent pending by Biosurvey Srl, Spin-off University of Palermo) realized with biodegradable plastic (bioplastic Mater-Bi). This system consists of a radial structure fixable on the seabed by a picket (Fig.1). The structure is modular with six arms on which a variable number of clips for optimal fixation of *P. oceanica* cuttings occurs. Ten modular systems with 30 cuttings and about 130 shoots per unit have been positioned at a depth of 6 m on two substratum typologies: sand with *C. nodosa* and *P. oceanica* dead *matte*. Transplant has been monitored monthly up to December 2013 by evaluating survival, detachment and mortality of cuttings, and shoot density.

Results and Discussion

Transplant monitoring showed no significant differences between substrata. In particular, both on sand with *C. nodosa* and *P. oceanica* dead *matte*, after twenty months from transplanting, cuttings survival was 94%, both mortality and detachment were about 3%, and shoot density per unit showed a slight increment than the starting one. Therefore, *P. oceanica* anchor modular system allows the rapid attachment and expansion as evidenced by high survival rates and density increasing. This new developed *P. oceanica* system was successful and effective for our transplanting. Indeed, although *P. oceanica* is slow-growing seagrass, after 1 year from transplanting an increase of shoot density has been detected. Moreover, anchor system, made with a new generation of bio-plastic, is totally biodegradable maintaining the same physical characteristics of plastics. This new material, unlike that of other transplant systems, does not release harmful residues in the environment. In addition, biodegradation of the system is compatible with cuttings rooting and their stabilization into the substratum. Therefore, transplanting by using this artificial underwater anchor system may be an effective technique to successfully restore *P. oceanica* habitat.

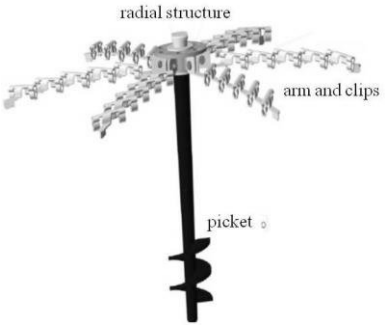

Fig. 1: ***Anchor modular system.***

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