UN environment

SPA/RAC

The Mediterranean Biodiversity Centre

PROCEEDINGS OF THE 6th MEDITERRANEAN SYMPOSIUM ON MARINE VEGETATION

ANTALYA, TURKEY, 14-15 JANUARY 2019

Technical partner

TURKISH MARINE RESEARCH FOUNDATION

Financial support

MAVA FONDATION POUR LA NATURE

Agostino TOMASELLO, PIRROTTA M., CALVO S.
Department of Earth and Marine Sciences, University of Palermo, Via Archirafi 18, 90123 Palermo,Italy.
E-mail: agostino.tomasello@unipa.it

CONSTRUCTION UNDERWATER LANDSCAPE BY USING *POSIDONIA OCEANICA* TRANSPLANTING COMBINED WITH INNOVATIVE ARTIFICIAL REEFS

Abstract

Interest concerning Artificial Reef (AR) habitats has greatly increased in the last few decades throughout the world with Italy representing the leading country in Europe for AR's research. In this study very innovative ARs able to host Posidonia oceanica *transplant cuttings were designed and positioned. Four AR systems were positioned in December 2014 along the south-eastern coast of Sicily. Furthermore, over each module 10* P. oceanica *cuttings, each one bearing at least three shoots, were fixed by an innovative system, opportunely adapted for hard substrate. After two years of monitoring, cuttings survival was about 70% with visible roots production strongly anchored to the concrete AR, while shoot mortality and detachment were very low. These results suggested that* P. oceanica *can be successfully employed to improve the aesthetic value of ARs, providing evidence that its transplanting on hard substrate is less difficult than previously thought and opening new perspectives for restoring damaged meadows settled also on rock.*

Key-words: seagrass, restoration, transplanting, artificial reef.

Introduction

Interest concerning Artificial Reef (AR) habitats has greatly increased in the last few decades throughout the world (Seaman & Sprague, 1991; Stone *et al.*, 1991; Seaman & Jensen, 2000) with Italy representing the leading country in Europe for AR's research. ARs have been mainly conceived for a variety of purposes (Baine, 2001; Bulleri & Chapman, 2010), including the increase of natural productivity by providing new habitats to aggregate organisms (Thierry, 1988; Paxton *et al.*, 2018), creation of habitats for desired target species (Sheehy, 1986) and protection of small/juvenile organisms and nursery areas (Seaman, 2000). However, in this field of research, very low attention has been addressed to the aesthetical and perceptive integration of the ARs within underwater landscape (Inglis *et al.*, 1999; Dinsdale & Fenton, 2006; Needham *et al.*, 2011).
Posidonia oceanica, an endemic seagrass of the Mediterranean Sea, is able to grow on different types of sea bottom, ranging from sand, which is easily penetrable by the roots, to rock, in which the very sturdy roots are able to enter through crevices (Bellan-Santini *et al.*, 1994; Hemminga & Duarte, 2000; Mazzella *et al.*, 1993). *P. oceanica* meadows can also develop on *matte*, a typical terraced formation built up by itself, consisting of intertwined rhizomes, roots and sediment (Boudouresque & Meinesz, 1982). Since the 1970s, various transplanting and seedling techniques with *P. oceanica* have been carried out for habitat restoration. Transplant success was found to be influenced by the nature of the substratum, with dead *matte* habitat showing the highest survival and growth rates (Terrados *et al.*, 2013), while, to our knowledge, the experiences of transplants on hard substrates are still poorly documented.

In the framework of PON TETIDE project (http://www.progettotetide.com), very innovative ARs able to host *P. oceanica* transplant cuttings were designed and positioned. In the present work, we report the results of a monitoring activity on the transplanted cuttings carried out also in the framework of Life SEPOSSO (http://lifeseposso.eu).

Materials and Methods

The study was carried out in the Gulf of Augusta (Syracuse, Italy, Fig. 1), an area exposed to multiple pollution sources due to Priolo-Augusta-Melilli petrochemical activities since '50. However, recently remediation activities, focused mainly on purification and proper waste water disposal along the coast, have improved water quality (Catra & Mollica, 1993). It was therefore possible to carry out different experiments aimed to test the possibility to restore the degraded habitat with the use of *P. oceanica* transplants.

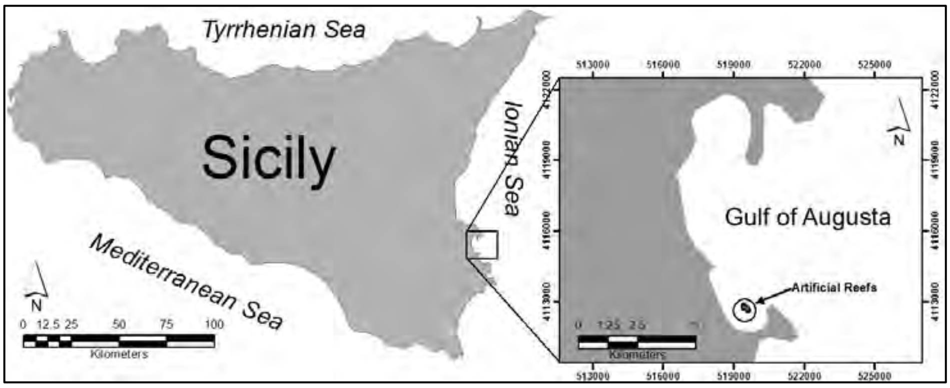

Fig. 1: Study area.

In this framework several ARs hosting *P. oceanica* transplant were positioned at about 13 m depth in December 2014. The AR design was chosen according to the characteristics of the study area and considering several aspects (i.e. hollow, size, material, shape). In particular, four ARs each one consisting of three modules of 10 tons, were located. These modules are made of reinforced concrete and composed by a common base of 2x3 m with multiple communicating shelters, and an upper form with three different heights (varying between 100and180 cm), to result shelters with different volumes, light and water movement (Fig. 2).

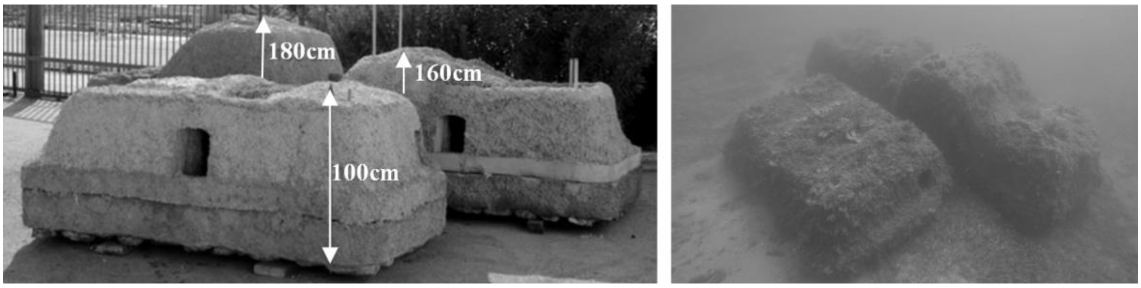

Fig. 2: AR sistems composed by three modules (*in situ* left).

In the same month, over each AR module 10 *P. oceanica* cuttings (Fig. 3), each one bearing at least three shoots, were fixed by an innovative system, opportunely adapted for hard substrate. Unfortunately, these transplants were soon after almost completely destroyed by illegal fishing activities. Then, a new equivalent transplant activity was again carried out in April 2016.

Fig. 3: *P. oceanica* anchor system on hard substrate (Ph. V. Raimondi).

From April 2016 to July 2018, monitoring activities by observations and measurements *in situ* were carried out to evaluate *P. oceanica* transplant performance in terms of establishment, detachment and mortality of cuttings, shoots number, leaf length. Moreover, elongation of plagiotropic rhizomes was recorded by repeated measures of the distance of the terminal apex from a fixed point on the anchoring support.

Results

For *P. oceanica* transplants on ARs positioned in the Gulf of Augusta, cutting establishment showed a decreasing trend during the monitoring period, with values of about 70% recorded in the final survey. Cuttings totally detached from the supports showed the opposite trend, reaching a final value of about 20% (Fig. 4a). The percentage of cuttings found dead was very low, reaching a final value of less than 4%.

The pattern of shoot number showed an initial increment occurred in July 2016 followed by a decrease to 44 shoots per support (Fig. 4b). Leaf length exhibited seasonal variations with the highest value in summer and the minimum in winter (Fig. 4c). Finally, plagiotropic rhizomes showed a progressive increment of length with initial steady state during the first eight months followed by a total increment of about 3 cm corresponding to an annual growth rate of 1.3 $cm \cdot yr^{-1}$ (Fig. 4d and Fig. 5).

Discussion and Conclusions

This study demonstrated that it is possible to combine ARs construction with *P. oceanica* transplanting activities, minimizing the visual impact on the underwater landscape by emulating the natural shape of the bottom. Despite the loss of cuttings in the first months after transplantation, due to the fishing activity, as similarly occurred in other areas (Pirrotta *et al.*, 2015), the subsequently transplanted cuttings exhibited good performance in terms of percentages of *P. oceanica* establishment (> 70%). The anchoring of the cuttings to the bottom favored the establishment and the expansion of the clones. This finding confirmed that *P. oceanica* has developed adaptive traits enabling to colonize hard substratum (Balestri *et al.*, 2015; Tomasello *et al.*, 2018) without the need for precursor assemblages (Badalamenti, *et al.*, 2015).

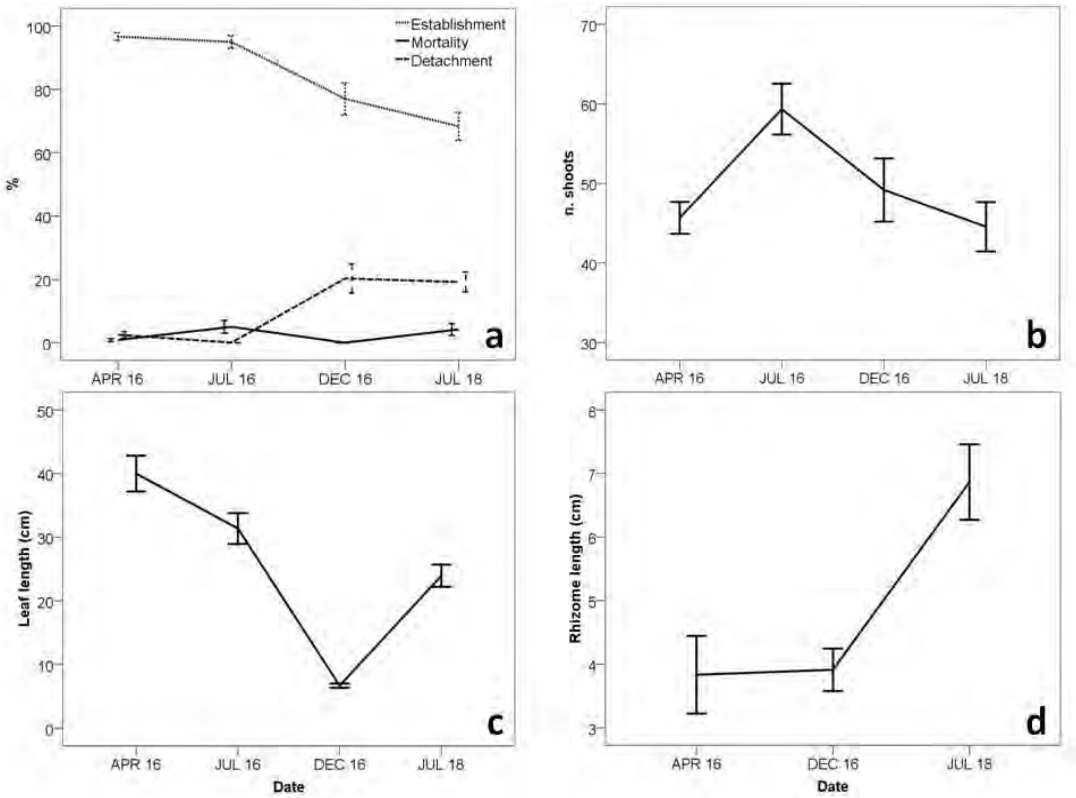

Fig. 4: Mean (± SE) percentages of establishment, detachment and mortality of cuttings (a), shoot number (b), leaf (c) and rhizome (d) length of *P. oceanica* cutting on AR.

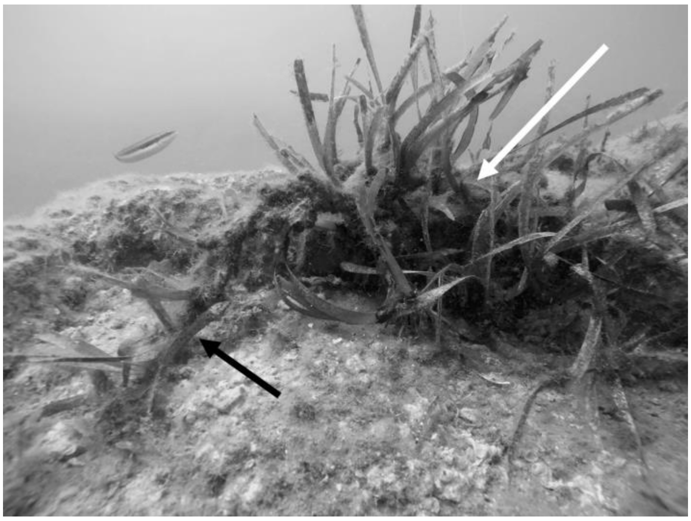

Fig. 5: Details of rhizomes growth on hard substrata above (white arrow) and beyond the anchoring support directly over the reef (black) (Ph. V. Raimondi).

The mortality recorded (about 4%) does not necessarily imply a low efficacy throughout the transplant, since this can be compensated over time by the elongation and ramification of the remaining cuttings (Calumpong & Fonseca, 2001). The growth rate of a seagrass clone increases continuously; therefore, the space occupied by a clone increases exponentially. Since *P. oceanica* is a long living species, its natural recovery is very slow (Pergent *et al.*, 2012) and the time to capture its resilience is often much longer than the conventional three years reported by most ecological studies (Cunha *et al.*, 2012). However, these results suggested that *P. oceanica* should be successfully employed to improve the aesthetic value of ARs (Fig. 6), providing evidence that its transplanting on hard substrate is less difficult than previously thought and opening new perspectives for restoring damaged meadows settled also on rock.

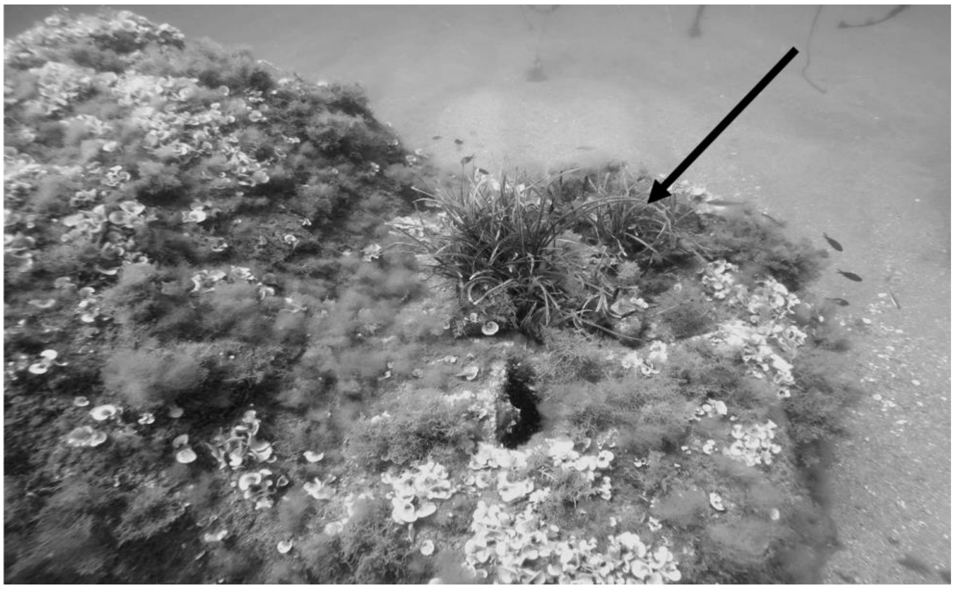

Fig. 6 - AR at 100% covered by community of algae and transplants of *P. oceanica* (arrow) (Ph. V. Raimondi).

Bibliography

BADALAMENTI F., ALAGNA A., FICI S. (2015) - Evidences of adaptive traits to rocky substrates undermine paradigm of habitat preference of the Mediterranean seagrass *Posidonia oceanica*. *Scientific Report*, 5: 8804.

BAINE M. (2001) - Artificial reefs: A review of their design, application, management and performance. *Ocean & Coastal Management*, 44: 241-259.

BALESTRI E., DE BATTISTI D., VALLERINI F., LARDICCI C. (2015) - First evidence of root morphological and architectural variations in young *Posidonia oceanica* plants colonizing different substrate typologies. *Estuar. Coast. Shelf Sci.*, 154: 205-213.

BELLAN-SANTINI D., LACAZE J.C., POIZAT C. (1994) - Les biocénoses marines et littorales de Méditerranée, synthèse, menaces et perspectives. *In*: *Collection Patrimoines Naturels, vol. 19*. Secrétariat de la Faune et de la Flore/MNHN: 1-246pp.

BOUDOURESQUE C.F., MEINESZ A. (1982) - Découverte de l'herbier de Posidonies. *Cahier du Parc national de Port-Cros*, 4: 1-79.

BULLERI F., CHAPMAN M.G. (2010) - The Introduction of Coastal Infrastructure as a Driver of Change in Marine Environments. *Journal of Applied Ecology*, 47: 26-35.

CALUMPONG H.P., FONSECA M.S., 2001. Seagrass transplantation and other seagrass restoration methods. *In*: Short F.T., Coles R.G., Short C.A. (Eds), *Global Seagrass Research Methods*. Elsevier, Amsterdam: 424-443.

CATRA M., MOLLICA E. (1993) - Valutazione di impatto ambientale sull'ambiente idrico del complesso I.S.A.B. S.p.A. di Gasificazione/Cogenerazione. Rapporto interno I.S.A.B.: 31 pp.

CUNHA A.H., MARBA N., VAN KATWIJK M.M., PICKERELL C.H., HENRIQUES M. BERNARD G., FERREIRA M.A., GARCÍA S., GARMENDIA J.M., MANENT P. (2012) - Changing Paradigms in Seagrass Restoration. *Restoration Ecology*, 20: 427-430.

DINSDALE E.A., FENTON D.M. (2006) - Assessing coral reef condition: eliciting community meanings. *Society and Natural Resources*, 19: 239-258.

HEMMINGA M.A., DUARTE C.M. (2000) - *Seagrass Ecology*. Cambridge University Press, UK: 298 pp

INGLIS G.J., JOHNSON V.I., PONTE F. (1999) - Crowding norms in marine settings: A case study of snorkeling on the Great Barrier Reef. *Environmental Management*, 24: 369-381.

MAZZELLA L., SCIPIONE M.B., GAMBI M.C., BUIA M.C., LORENTI M., ZUPO V., CANCEMI G. (1993) - The Mediterranean seagrass *Posidonia oceanica* and *Cymodocea nodosa*: a comparative overview. *In*: Ozhaen E. (Ed.), *Proceedings of the First International Conference on the Mediterranean Coastal Environment*. MEDCOAST 93: 103-116.

NEEDHAM M.D., SZUSTER B.W., BELL C.M. (2011) - Encounter norms, social carrying capacity indicators, and standards of quality at a marine protected area. *Ocean and Coastal Management*, 54: 633-641.

PAXTON A.B., REVELS L.W., ROSEMOND R.C., VAN HOECK R.V., LEMOINE H.R., TAYLOR J.C., PETERSON C.H. (2018) - Convergence of fish community structure between a newly deployed and an established artificial reef along a five-month trajectory. *Ecological Engineering*, 123: 185-192.

PERGENT G., BAZAIRI H., BIANCHI C.N., BOUDOURESQUE C.F., BUIA M.C., CLABAUT P., HARMELIN-VIVIEN M., MATEO M.A., MONTEFALCONE M., MORRI C., ORFANIDIS S., PERGENT-MARTINI C., SEMROUD R., SERRANO O., VERLAQUE M. (2012) - *Mediterranean seagrass meadows: resilience and contribution to climate change mitigation. A short summary*. IUCN publ, Gland, Málaga, Spain: 40 pp.

PIRROTTA M., TOMASELLO A., SCANNAVINO A., DI MAIDA G., LUZZU F., BELLISSIMO G., BELLAVIA C., COSTANTINI C., ORESTANO C., SCLAFANI G., CALVO S. (2015) - Transplantation assessment of degraded *Posidonia oceanica* habitats: site selection and long-term monitoring. *Mediterranean Marine Science*, 16(3): 591-604.

SEAMAN JR W., JENSEN A. (2000) - Purposes and practices of artificial reef evaluation. IN: Seaman W. Jr (Ed.), *Artificial reef evaluation with application to natural marine habitats*. CRC Press, Boca Raton, Florida: 1-19.

SEAMAN JR.W. SPRAGUE L.M. (1991) - *Artificial habitats for marine and freshwater fisheries*. Academic Press: San Diego: 285 pp.

SEAMAN W.J. (2000) - *Artificial Reef Evaluation with Application to Natural Marine Habitats*. CRC Press, Boca Raton, FL: 260pp

SHEEHY D.J. (1986) - New approaches in artificial reef design and applications. *In*: D'itri F.M. (Ed.) *Artificial reefs: marine and freshwater applications*. Lewis Publishers, Inc., Michigan, USA: 253-263.

STONE R.B., SPRAGUE L.M., MCGURRIN J.M., SEAMAN W. JR (1991) - Artificial habitats of the world: synopsis and major trends. *In*: Seaman W. Jr, Sprague L.M. (Eds.), *Artificial Habitats for Marine and Freshwater Fisheries*. Academic Press, San Diego, California: 31-60.

TERRADOS J., MARIN A., CELDRÁN D. (2013) - Use of *Posidonia oceanica* seedlings from beach-cast fruits for seagrass planting. *Botanica Marina*, 56(2): 185-195.

THIERRY J.M. (1988) - Artificial reefs in Japan - A general outline. *Aquacultural Engineering*, 7: 321-348.

TOMASELLO A., PERRONE R., COLOMBO P., PIRROTTA M., CALVO S. (2018) - Root hair anatomy and morphology in *Posidonia oceanica* (L.) Delile and substratum typology: First observations of a spiral form. *Aquatic Botany*, 145: 45-48.