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Restoration experiment of *Zostera marina* L. in a subtropical coastal lagoon

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ABSTRACT

Zostera marina is the dominant seagrass species in coastal lagoons on the western coast of Baja California Peninsula, and due to its coastal location it is threatened by natural and anthropogenic factors, as is happening in Puerto San Carlos, B.C.S., where a fish cannery unloads its wastewater to the beach. Apparently an extensive intertidal meadow replacement was established by great amounts of green macroalgae. We evaluated the possibility to mitigate the impacts of this cannery with transplants of *Z. marina* meadow using adult plants. The transplant experiment was made in two different seasons for which two undisturbed donor meadows were chosen: El Cuervo and San Carlitos. The winter one obtained a 30% and in San Carlitos 90% after 13 months and the autumn transplant in San Carlos obtained a 0% of survival after 3 months. The results of these transplant activities were reflected in the shoot density at the end of the experiment (San Carlos was of 482 shoots/m^2 and San Carlitos of 818 shoots/m^2s and agree with the density of the natural meadows. This experiment shows that it is possible to develop a small-scale seagrass restoration as mitigation for Baja California coastal lagoons which are under severe threat for coastal development.

1. Introduction

Seagrasses, like other wetlands on the coastal zone, are susceptible to the effects of human activities like pollution, which modifies the sediment condition besides contributing to nutrient excess (Mann, 1982). Pollution could decrease meadows' vitality since the excessive contribution of nitrogen and ammonium in the water column can inhibit growth, productivity and survival. In these cases the effects can be amplified by elevated temperatures and salinities (Short, 1983; Taylor et al., 1995; van Katwijk et al., 1997; Touchette et al., 2002). The result of adverse conditions might increase the cover of epiphytes, reducing the availability of light and nutrients on the leaves, which could affect photosynthesis and therefore oxygen concentration in sediment and increase sulfide, causing their deterioration and death of seagrass in short or long term (Carlson et al., 1994; Pedersen et al., 2004).

When anthropogenic activities cause damages, there are two possible ways of action: restoration to "return to a previously existing natural or altered condition from a disturbed or totally altered condition by some action", or mitigation that involves "restoration, creation or enhancement of the system to compensate for permitted wetland losses" (Fonseca et al., 1998), which is an action to prevent or diminish a damage and is required generally by the federal governments of some countries (Clark, 1996). However, limited information on subtropical areas is available.

Large-scale restoration of seagrass systems has occurred mainly in developed countries, such as the United States (Fonseca et al., 1996; Orth et al., 1999; Gayaldo et al., 2001), Australia (Kirkman, 1999; Meehan and West, 2002) and the Netherlands (Bos et al., 2005). Some of these methods are still at an experimental level because they are continually tested for different seagrass species, and their success level depends mainly on each site characteristics (Hawkins et al., 1999). In Mexico seagrass restoration experience is limited to a few trials in Baja California and the Caribbean, where only the first one was done as a restoration experiment (Cabello-Pasini, 1984; van Tussenbroek, 1996).

Although the importance of the protection of wetlands has been recognized, Mexico does not have any law or norm that protects these ecosystems and establishes clearly how restoration activities must be made, with the exception of the NOM-022-SEMARNAT-2003 that protects mangroves and wetlands (in which seagrasses and macroalgae are briefly mentioned).

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Carrera-González and De la Fuente (2003) suggest that large extensions of *Zostera marina* that exist in Bahía Magdalena (approx. 14,000 ha), mainly are intertidal beds. Even so, in the intertidal zone towards the south of Puerto San Carlos, an ample *Z. marina* bed existed and has been disappearing in the last 10 years (Riosmena-Rodriguez, personal observation, October 1989). This area is right on the influence zone of the residual water pen unloading from the fish cannery of the port (Boudrias, personal communication). In spite of this, there exist no historical registries of populations of this zone, water quality and its importance in recruitment of commercially important species (like mollusks and fish that are widely exploited).

Therefore the goal of this paper is determined if *Z. marina* populations can be restored in a subtropical area by transplanting adults.

1.1. Study area

The Magdalena-Almejas lagoon complex is on the western coast of Baja California Sur, Mexico. This complex covers an area of 114,600 ha and it is divided into three zones: the northwest, composed by estuaries and channels like Santo Domingo, the central zone called Magdalena Bay which is connected with the sea by a mouth of deep channel and the south zone, Almejas Bay, which connects to the sea by a brief channel (Félix-Pico, 1993). The system is generally shallow; depth at most channels is around 3 m and in the main channel it is about 10 m. This anti-estuarine system is characterized by elevated temperatures and salinities due to high evaporation rates mainly in the shallower zones in the bay (Lluch-Belda et al., 2000). This work was done in the boundary between the Santo Domingo and the Magdalena Bay zones (Fig. 1).

Puerto San Carlos is the principal population center in this bay area, where there are two industrial fishing plants. In these plants, sardine and tuna are canned (mainly in tomato sauce or oil), frozen and in a smaller degree, fish flour is prepared (Guzmán-Vizcarra, 2000). In spite of having a treatment plant for residual water, this company frequently throws out the wastewater of fish processing, creating an impact on the near beach and sea (personal observation).

2. Methods

Transplants were carried out in two different seasons (autumn 2005 and winter 2006) and two donor meadows were chosen: (1) located at north of the Santo Domingo Channel (El Cuervo, EC 24°55′N, 112°09′W) and (2) San Carlitos (SCa) located at the entrance of the same name estuary (24°48′58″N, 112°09′08″ W).

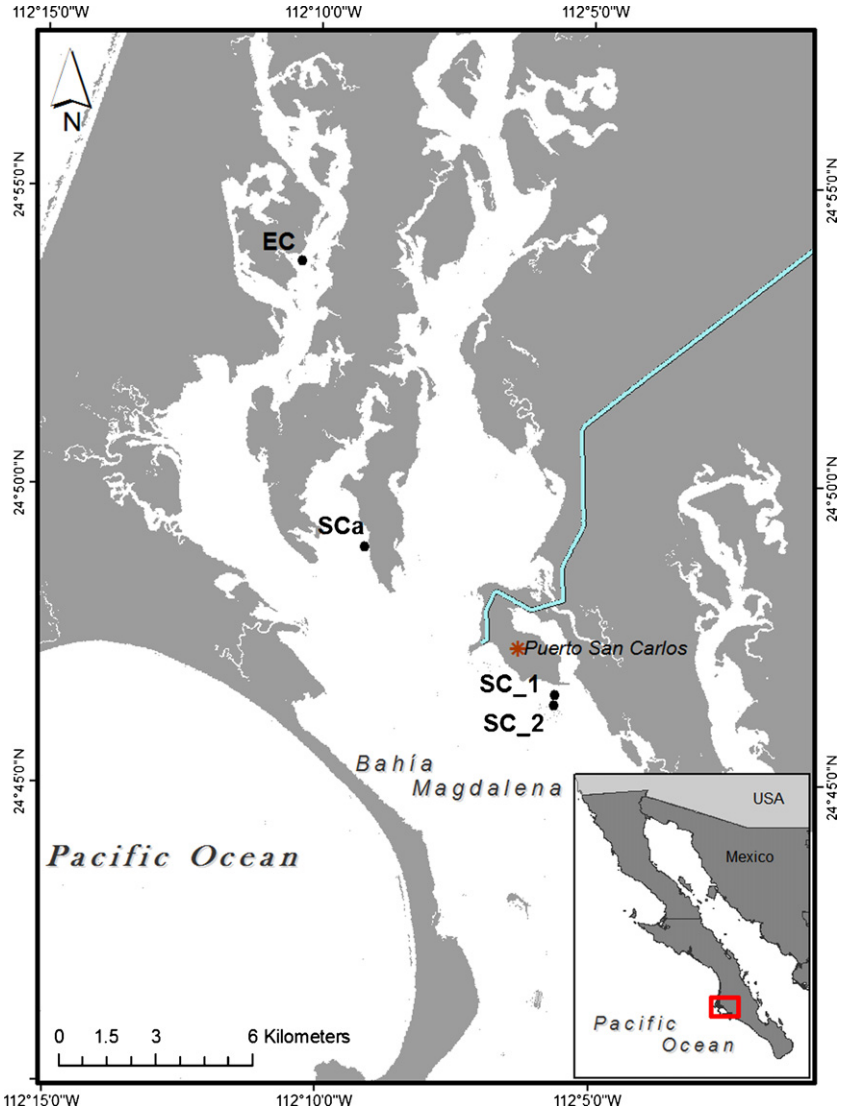

Fig. 1. Location of the transplants sites in the northwest zone of Magdalena Bay.