Spatial dynamics of *Zostera noltii* over a 5-year period of fluctuating salinity in the Vaccarès lagoon, France

[1]GRILLAS P., [1]CHARPENTIER A., [2]AUBY I., [3]LESCUYER F. and [3]COULET E.
[1]Station Biologique La Tour du Valat, Le Sambuc 13200 Arles, France
[2]Ifremer, Arcachon, France; [3]SNPN, Réserve Nationale de Camargue France

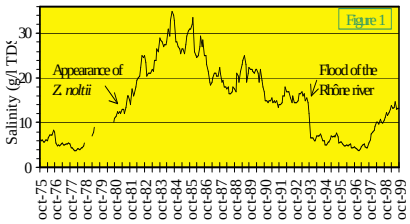
Abstract

During a 5-year survey in the Vaccarès lagoon, a successive period of decrease and increase in water salinity was associated with a decline and progressive recovery of a Z. noltii meadow. A negative correlation between cover index and water depth suggests that light availability was a limiting factor for plant growth over this period. The persistence of turbid water due to the lack of flocculation of suspended sediments may explain the decline of the seagrass meadow over the decrease in salinity.

Introduction

We investigated changes in spatial distribution of *Zostera noltii* over a period of fluctuating salinity in the Vaccarès lagoon, Southern France. The Vaccarès is a large and shallow lagoon (surface area: 70 km², depth up to 2 m) with fine sediment, rich in silt and clay. It collects drainage water from the Rhône delta and is indirectly connected to the Mediterranean Sea through an other lagoon.

Since 1980, increased water salinity, due to reduced freshwater inputs, has been associated with the development of a meadow of *Zostera noltii*. During the winter 1993-94, a massive freshwater input due to a major flood of the Rhône river resulted in a substantial decrease in water salinity. Water salinity further slowly decreased until 1997, due to heavy rainfall, and then progressively increased until 1999 (Figure 1). The aim of this study was to determine changes in maximum depth penetration and cover of *Z. noltii* in relation to decrease and increase in water salinity.



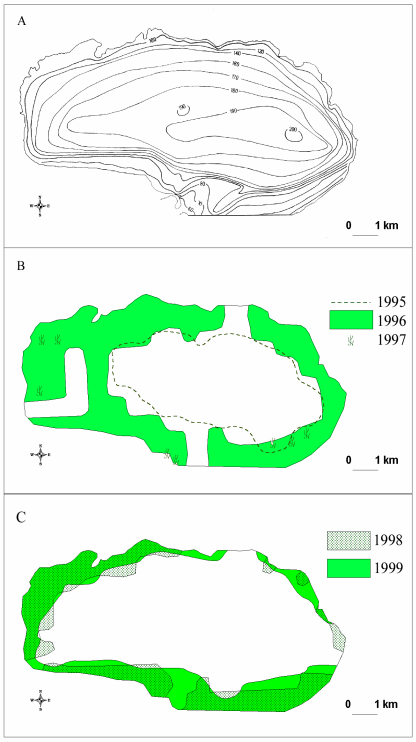
Methods

In 1995, water depth was measured at the deepest stations where *Z. noltii* were found along transects radiating from the centre of the lagoon, but no cover measurement was done.
Sampling each summer from 1996 to 1999 was done on a grid of stations 0.33 minute apart. For each station, the cover of *Z. noltii* was estimated in 10 quadrats (50 x 50 cm) randomly placed (cover index 0 : absent, 1 : <5%, 2 : 5-25%, 3 : 25-50%, 4 : 50-75%, 5 : >75%) and the water depth was measured.

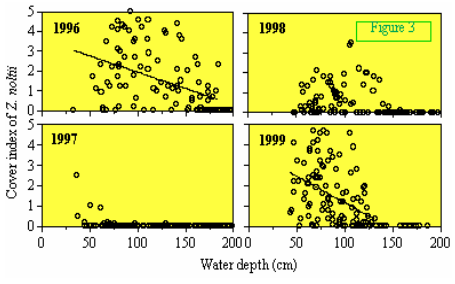
Results

Spatial expansion (Figure 2) :
In 1996, the spatial extension of *Z. noltii* was slightly reduced in comparison with 1995. In 1997, *Z. noltii* had almost totally disappeared. Only eleven stations persisted in shallow water. In 1998, *Z. noltii* recolonized borders of the lagoon except in the northeast part . In 1999, almost all of the lagoon borders were colonized.

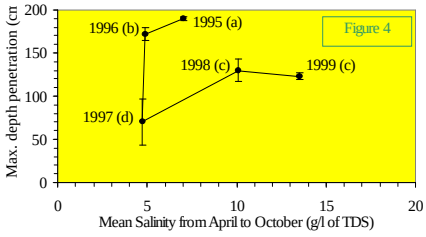
Figure 2: (A) Bathymetry of the Vaccarès lagoon in centimetres. (B) Maximum depth penetration of *Z. noltii* in 1995, spatial expansion of *Z. noltii* meadow in 1996, and location of the remaining stations of *Z. noltii* in 1997. (C) Spatial expansion of *Z. noltii* meadow in 1998 and 1999.



Cover index (Figure 3) :
In 1996, the cover index (see method) was significantly negatively correlated with water depth ($r^2 = 0.2$, n = 102, F = 23, p <0.001). In 1997 and 1998, cover indices were low and not correlated with water depth. In 1999, cover indices were higher than in 1998 and again significantly negatively correlated with water depth ($r^2 = 0.2$, n = 114, F = 26, p<0.001).



Maximum depth penetration (Figure 4) :
The maximum depth penetration was estimated for each year by calculating the mean water depth of the 10 deepest stations of *Z. noltii*. Over the 5-year period, maximum depth penetration changed from year to year along with mean water salinity during growing seasons. (Means +/- S.D. with different letters are significant different (p<0.05)).



Discussion

In the Vaccarès lagoon, salinity fluctuations were associated with consistent changes in the extension of *Z. noltii* meadow. In 1997, when salinity reached the lowest values (i.e. about 4.5 g/l TDS), *Z. noltii* had almost totally disappeared. Both in 1996 and 1999, the cover of *Z. noltii* was limited by water depth, suggesting a classical light limiting factor. The decline of seagrass (1995-1997) may have resulted from decreased light availability. During winter 1996-1997 concentrations of suspended sediments reached mean values above 100 mg/l (when wind speed below 3 m/s, unpublished data), probably resulting from salinity driven decreased flocculation of suspended sediment. The substantial loss of seagrass in 1997, contrasted with gradual changes during the 1993-1996 period (Fig 2, Fig.4 and unpublished data), suggesting a threshold effect around 5 g/l TDS of salinity on flocculation.

However, two successive growing seasons (1995 and 1996) in conditions of low light availability may have weakened the meadow and may have contributed to the decline in 1997. No direct detrimental effect of low salinity on *Z. noltii* could be detected and the remaining plants were healthy but limited to shallow depths.
Maximum depth colonized by seagrasses in 1998 and 1999 did not match the values attained in previous years. However the sharp increase in 1998 suggests availability of vegetative or sexual propagules from nearby habitats and/or seed pools. From 1999 onward, after this first increase, slow colonization of the meadow is expected, involving processes such as vegetative spread and feedback effect of the vegetation on hydrodynamics and suspended sediment.