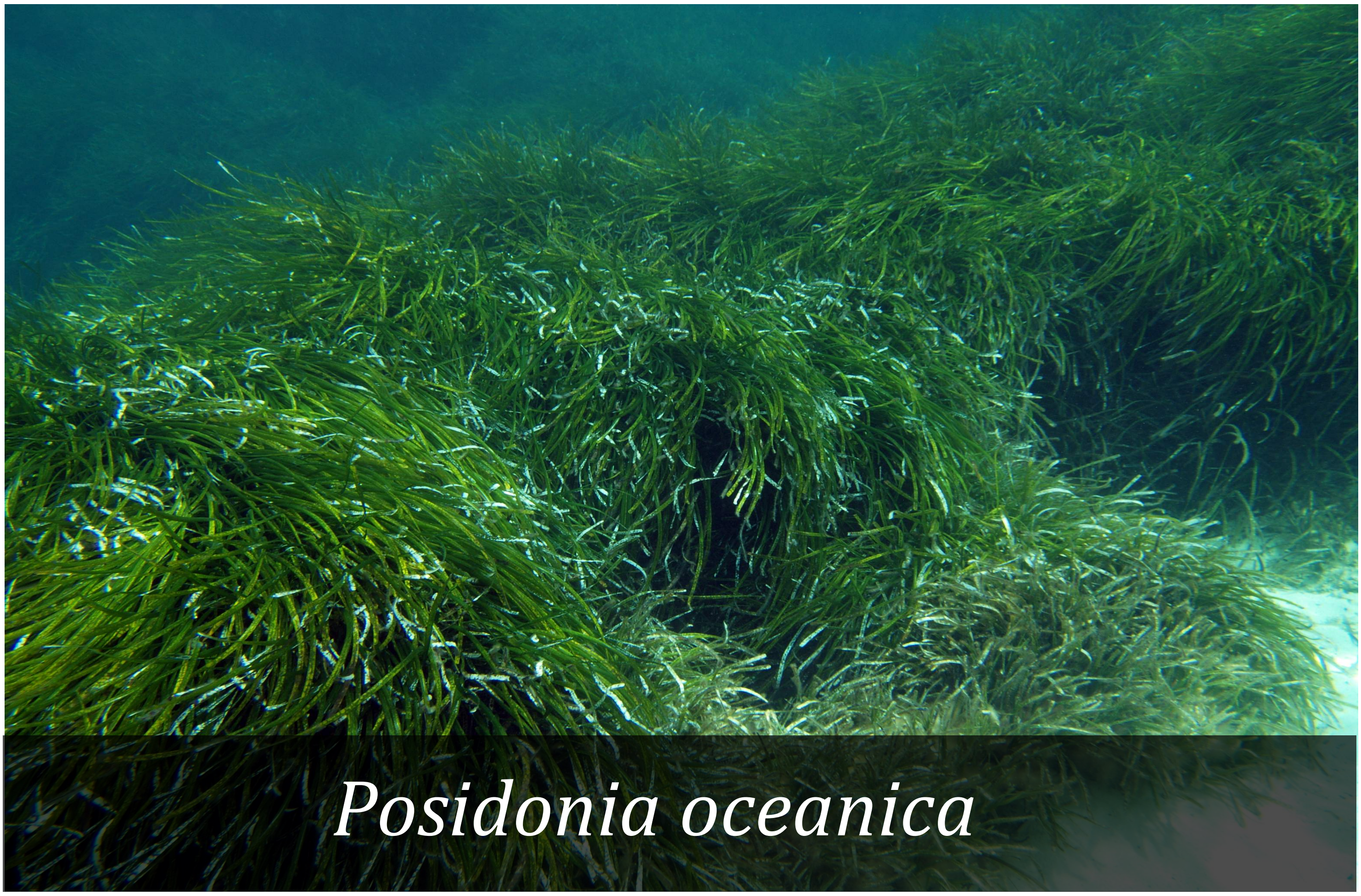
CHAPTER 11



Posidonia oceanica

Teresa Alcoverro[1], Jordi Pagès[1], Alessandro Gera[1], Simone Farina[1], Guillem Roca[1], Marta Pérez[2] and Javier Romero[2]

[1]Centro de Estudios Avanzados de Blanes. Consejo Superior de Investigaciones Científicas. [2]Departament d'Ecologia, Universitat de Barcelona.

Abstract
The aim of this work is to characterise the effects of the storm that took place on the 26 December 2008 on the *Posidonia oceanica* meadows of the northern Catalan coast (Costa Brava). *P. oceanica* showed a relatively low tolerance to burial. Beyond just 4 cm of burial, the plant quickly began to lose 50% of their shoots, and beyond 6 cm, mortality was nearly complete. The overall effect has been very significant with a loss of 23% of the meadows surface, mainly concentrated in the in shallow areas of the meadows. This loss is very significant considering the remarkably low recovery potential of this globally endangered seagrass species.

Image: *Posidonia oceancia* meadow at Es Pujols, Formentera, by MA Mateo

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The effects of 26th December 2008 storm on Costa Brava *Posidonia oceanica* ecosystems

By

Teresa Alcoverro[1*], Jordi Pagès[1], Alessandro Gera[1], Simone Farina[1], Guillem Roca[1], Marta Pérez[2] and Javier Romero[2]

[1] Centre d'Estudis Avançats de Blanes. CEAB-CSIC. Consejo Superior de Investigaciones Científicas. Acceso a la Cala S. Francesc 14. 17300 Blanes, Spain.
[2]Departament d'Ecologia, Universitat de Barcelona. Avda. Diagonal 645, 08028 Barcleona, Spain.
*teresa@ceab.csic.es

Resumen

El estado de las praderas de fanerógamas marinas se encuentra estrictamente relacionado con la dinámica del sedimento. Las tormentas afectan a las praderas de fanerógamas marinas principalmente en dos maneras: mediante el enterramiento o el arrancamiento de los haces. El objetivo de este trabajo es definir los efectos de la tormenta que hubo el día 26 de diciembre de 2008 en las praderas de *Posidonia oceanica* de la costa norte de Catalunya (Costa Brava). *P. oceanica* mostró una tolerancia relativamente baja a los niveles de enterramiento, sufriendo una pérdida de haces de más del 50% a partir de los 4cm y una mortalidad casi total desde los 6cm. Las consecuencias de la tormenta han sido muy significativas con una pérdida del 23% de la superficie de las praderas estudiadas, especialmente concentrado en las zonas someras de las praderas. Esta pérdida es marcadamente significativa, especialmente si tenemos en cuanta el lento potencial de recuperación.

Abstract

The state of seagrass meadows is closely linked to sediment dynamics, and they are very exposed and sensitive to changes in sedimentation. Storms damage seagrass meadows in two main ways: burial and uprooting of shoots. The aim of this work is to characterise the effects of the storm that took place on the 26 December 2008 on the *Posidonia oceanica* meadows of the northern Catalan coast (Costa Brava). *P. oceanica* showed a relatively low tolerance to burial. Beyond just 4 cm of burial, the plant quickly began to lose 50% of their shoots, and beyond 6 cm, mortality was nearly complete. The overall effect has been very significant with a loss of 23% of the meadows surface, mainly concentrated in the in shallow areas of the meadows. This loss is very significant considering the remarkably low recovery potential of this globally endangered seagrass species.

Introduction

The state of seagrass meadows is closely linked to sedimentary dynamics. Seagrasses can colonise and dominate unstable sandy sediments thanks to their vertical rhizome growth, which protects them from being buried in the sand, and a root system that anchors them firmly into the substrate (Manzanera et al. accepted). However, living in sandy sediment environments also means that seagrasses are very exposed and sensitive to changes in sedimentation.

Well established seagrass meadows reach equilibrium when the sediment influx is balanced in relation to the vertical rhizome growth (Gacia & Duarte 2001). Excessive sediment influxes can reduce the seagrasses' ability to adjust with vertical rhizome growth, so that meadows become totally or partially buried. Water turbidity may also increase, which greatly alters the growth and photosynthetic potential of seagrass species (Duarte et al. 1997, Duarte 2002, Cruz-Palacios & van Tussenbroek 2005).

The seagrass *Posidonia oceanica* is a key species in the Mediterranean Sea, and forms extensive meadows that provide crucial habitats for many species, prevent coastal erosion and act as an important carbon sink (Mazzella et al. 1989, Vizzini et al. 2002, Duarte et al. 2005). This species is also characterised by a large canopy and a low rhizome elongation rate (ranging from 0.5–0.7 cm yr−1 to 1.5–2 cm yr−1; Jeudy de Grissac & Boudouresque 1985), which could limit its capacity to recover or respond to sediment burial. Like many other seagrass ecosystems worldwide (Waycott et al. 2009), *P. oceanica* meadows are critically endangered due to increased anthropogenic

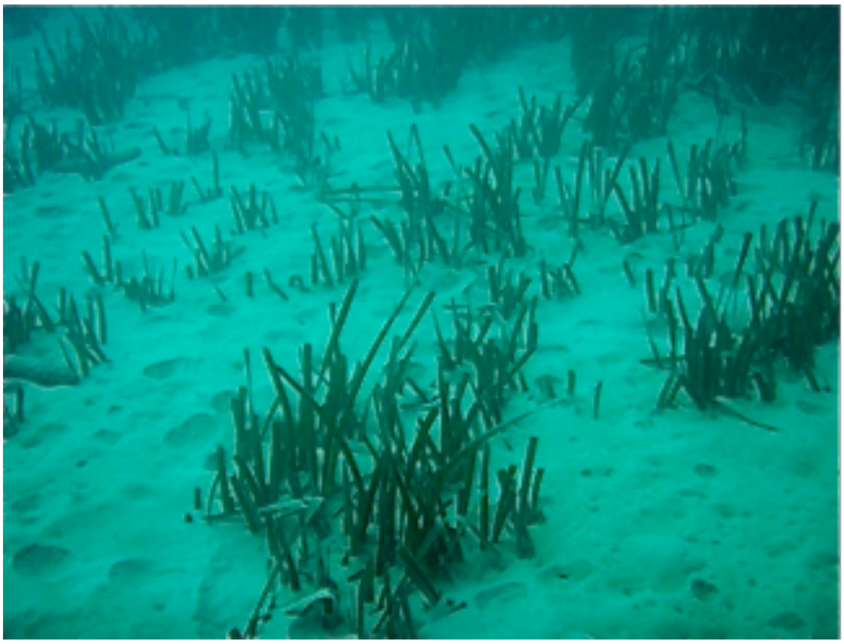

Figure 1. Burial of *Posidonia oceanica* shoots in a meadow of the northern Catalan coast.

pressure, and have been substantially reduced throughout the Mediterranean (Ruiz et al. 2009). In fact, due to their ecological importance, the numerous anthropogenic threats they are exposed to, and their low recovery capacity, *P. oceanica* beds have been declared a protected habitat within the European Habitats Directive (92/43/CEE). Natural disturbances like storms and anthropogenic coastal interventions such as beach nourishment or sand dredging result in sediment being deposited periodically on seagrass meadows (Erftemeijer & Lewis 2006, González-Correa et al. 2009).

Storms damage seagrass meadows by two main actions: burial and uprooting of shoots (Figure 1). Moreover, they not only affect the plant but also their associated living assemblages (Cruz-Palacios and Van Tussenbroek, 2005). Burial is not always critical, the extent of the damage depends on the amount of sediment that is deposited on the meadow and the tolerance of each plant (Cabaço *et al.*, 2008). Determining burial thresholds and the extent of the effect of burial based on the tolerance threshold is a way of determining part of the effect of burial on meadows for which there is not enough data on cover. This is the case

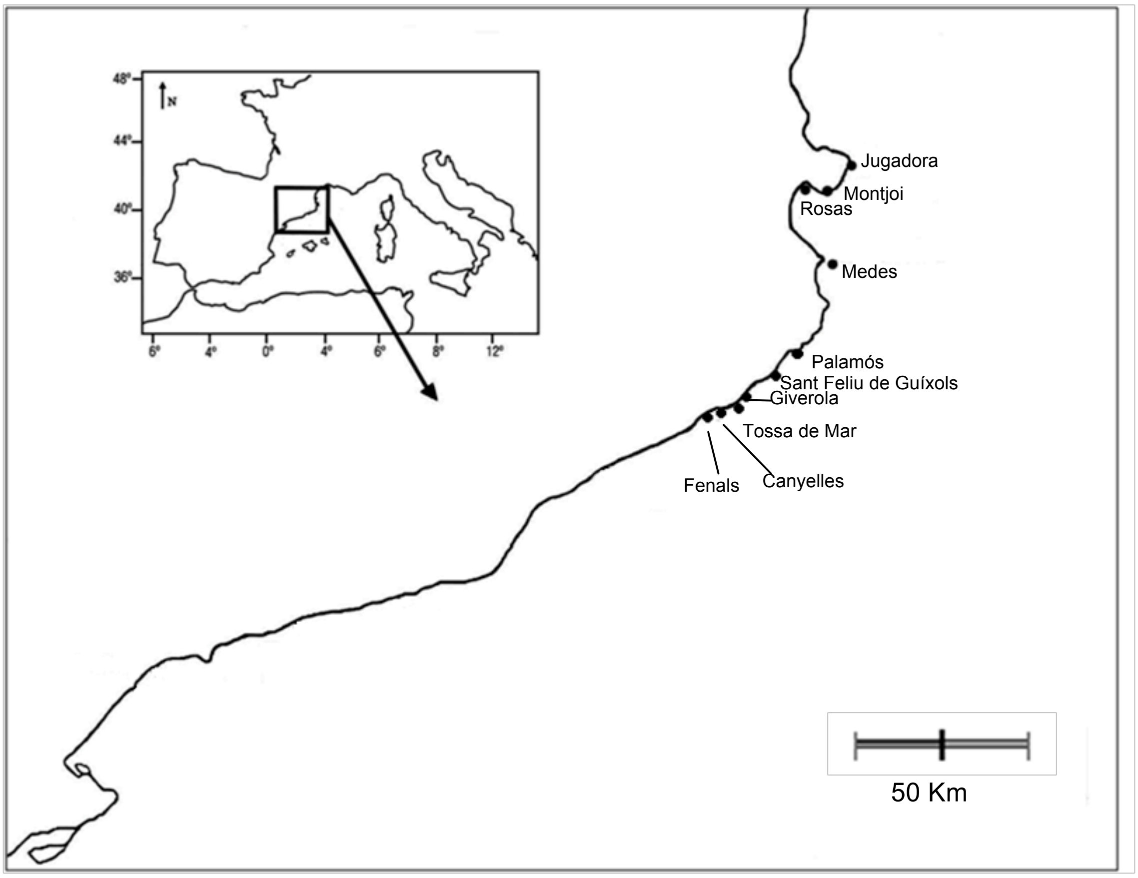

Figure 2. Localities in the northern Catalan coast were *Posidonia oceanica* meadows were studied.

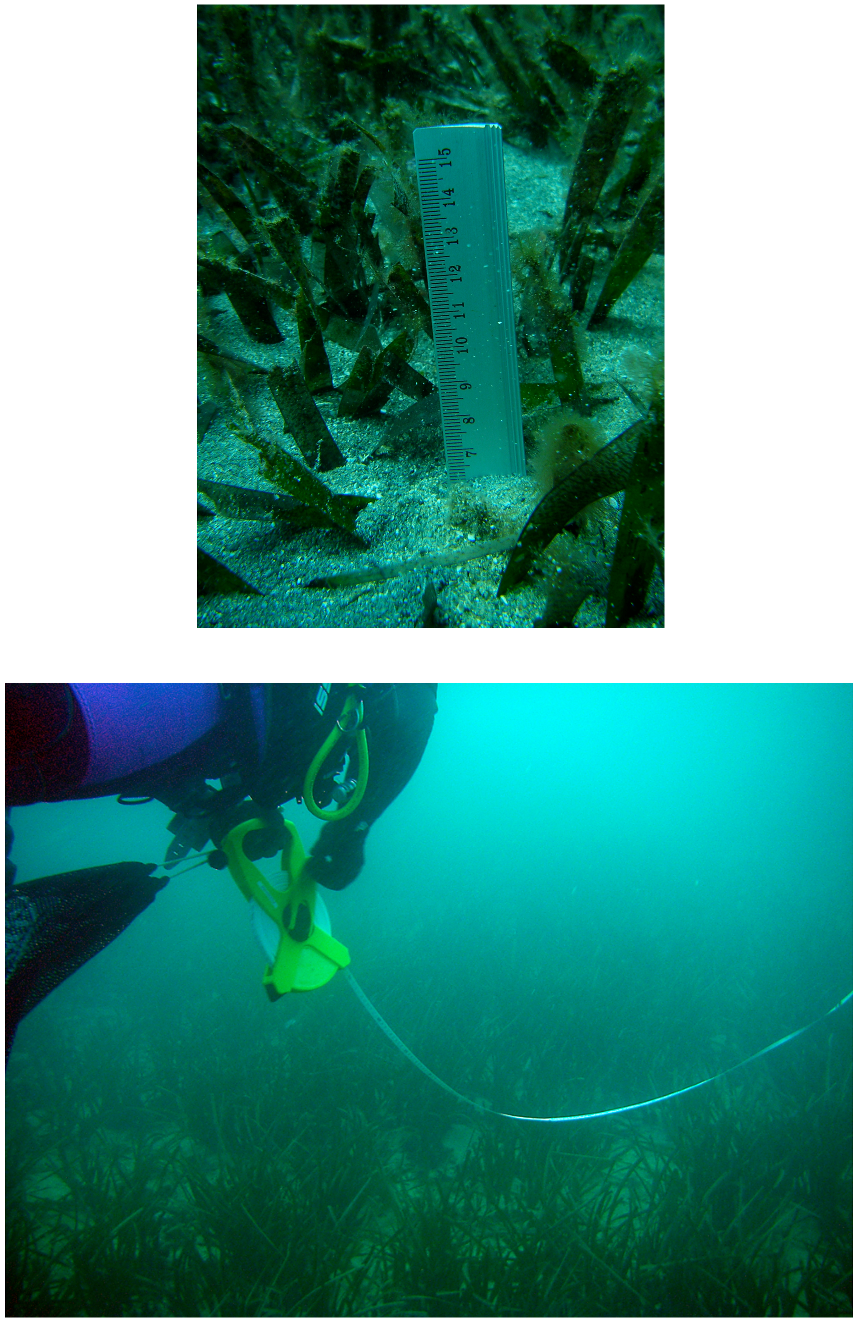

Figure 3. Measuring the degree of burial and meadow patch area in a *P. oceanica* meadow of the Costa Brava.

of the coastline that was affected by Sant Esteve storm (2008).

The aim of this work is to characterise the effects of the storm that took place on the 26 December 2008 on the *Posidonia oceanica* meadows of the northern Catalan coast (Costa Brava). The work has three main objectives: (i) to determine the burial tolerance thresholds for *Posidonia oceanica*; (ii) to determine the extent of burial in a set of meadows randomly selected along the northern Catalan coast; and (iii) to determine the effect on the associated fauna.

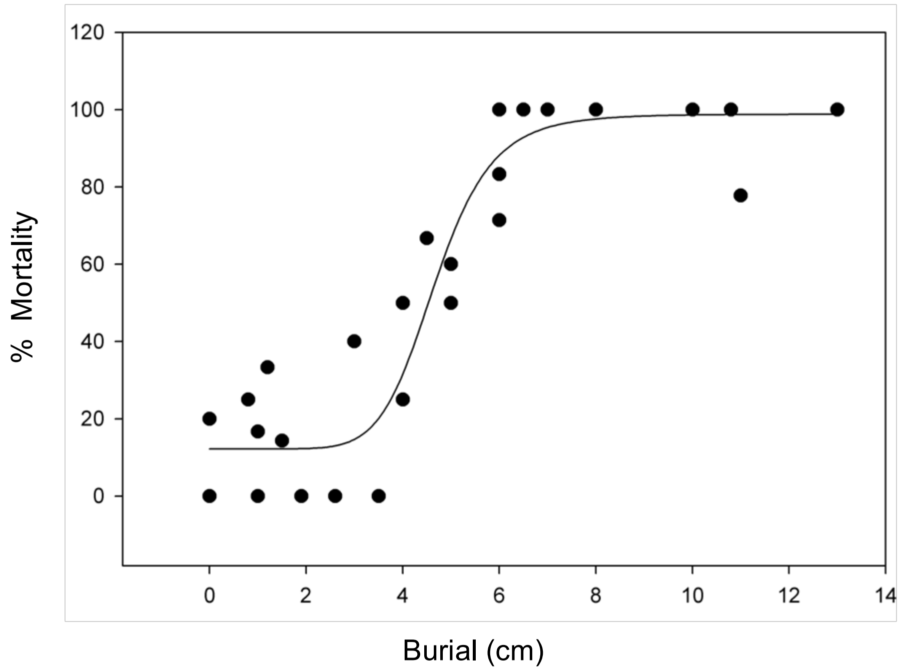

Figure 4. Relationship between burial and percentage of mortality of shoots of *Posidonia oceanica* in 15 x 15 cm quadrats in Cala Canyelles (n = 23).

Materials and Methods

Evaluating the burial thresholds

This study was carried out in Cala Canyelles meadow at 17 m depth. Burial thresholds were determined in different areas that were buried to different degrees after the storm (5 months later). The number of living and dead shoots was counted in quadrats of 15x15 cm placed randomly inside the meadow in areas that were buried to different extents (including burial level 0cm). These values allowed us to determine the percentage of plant mortality that can be attributed to each level of burial stress. The SCUBA divers determined the degree of burial by placing their bare hand into the sediment and feeling for the ligulae of the buried leaves, then measuring the distance (in cm) between this point and the surface of the sediment with a ruler.

The regional extent of burial due to the storm

In order to monitor the regional extent of burial, we randomly visited ten meadows in the northern part of the Catalan coast, Costa Brava (Figure 2). At each site, SCUBA divers swum a minimum of 6 transects of 50 m in different directions searching for buried patches. We considered patches to be buried when the plants were covered with 10 cm of sediment or more.

Checking the impact of sand burial in different locations

Six 40 x 40 cm plots were deployed in four locations (Giverola shallow, Fenals shallow, Canyelles deep, and Palamós deep) right after the storm in order to ascertain how the degree of

Table 1. Depth and burial percentage in the *Posidonia oceanica* meadows surveyed as observed during visual transects in each locality.

Locality	Depth (m)	% Burial (> 10 cm)
Jugadora	20	0
Montjoi	23	0
Roses	22	0
Medes	7	20
Medes	15	0
Palamós	16	10
St. Feliu	23	0
Giverola	6	20
Tossa	14	10
Canyelles	20	20
Fenals	25	5
Fenals	8	30

burial due to the storm affected the long-term survival of P. oceanica shoots. Three categories with two replicates each (a total number of 6 quadrats per site) were established according to the degree of burial (0-5cm; 5cm-10cm; >10cm). The number of surviving shoots (although more or less buried) was counted. The same procedure was repeated several months later.

The collateral effects on the associated fauna

The total abundance and size of sea urchins was assessed 4 months before and 6 months after the storm in 19 *P. oceanica* patches located in the meadow of Fenals at 8 m depth.

Results and discussion

Evaluating the burial thresholds

Posidonia oceanica showed a relatively low tolerance to burial. From just 4cm the plant quickly began to lose shoots, and from 6cm on, mortality was nearly complete. Shoots are not lost continuously. They showed a first phase of tolerance, in which all the shoots remained alive, a second phase of partial mortality (tolerance threshold), and a final phase of total mortality (Figure 4).

Regional extent of the burial due to the storm impact

Not every meadow from the northern coast of Catalonia was buried as a consequence of the storm. Most of the deep meadows showed low levels of burial (around 5% of their total area on average), while all the meadows studied buried above 10m were affected by burial (23% of their area on average; Tables 1 and 2). As we only considered as buried those areas with shoots covered with more than 10 cm of sediment, these burial estimates may be interpreted as a conservative estimate of the area of the meadow that was lost (as a burial level of around 6 cm already implies important shoot mortality). The percentage of area buried would have been even higher if we had considered burial levels below 10 cm.

Table 2. Mean percentage of the area buried in shallow (n=3) and deep (n=9) meadows.

Depth	Mean % of burial
Shallow	23
Deep	5

Table 3. Total abundance of sea-urchin *Paracentrotus lividus* individuals in 19 patches of *Posidonia oceanica* at Fenals before and after the storm. It is also included the percentage of loss.

Total abundance of *P. Lividus* before the storm	302
Total abundance of *P. lividus* after the storm	164
% Loss	46

Checking the impact of sand burial in different locations

We have not yet surveyed all the permanent plots and therefore the percentage of shoots that have effectively died has not yet been determined precisely. However, several visits to some of the study areas (e.g. in Giverola and Fenals) have shown that the final mortality rate is around 100% in the plots where burial exceeded 10 cm and also in the plots with a burial of 5-10 cm, whereas mortality rates are lower in plots that are less buried.

The collateral effects on associated fauna

The sea urchin population from the control patches of *P. oceanica* from Fenals (a meadow that was particularly affected by the storm and lost 30% of the total cover) decreased by 46% after the storm (Table 3). This could be indicative of the effects of the Sant Esteve storm on other assemblages associated with *P. oceanica* meadows, especially at shallow depths.

Conclusions

Burial of shoots beyond 6 cm had dramatic effects on *P. oceanica*. It can be concluded that the effects of the extreme storm of 26 December 2008 on the meadows along the northern Catalan coast were clearly negative and it is possible that the associated fauna has also been severely affected (see also Chapter 12). The effect has been particularly strong in shallow areas of the meadows. We should bear in mind that a loss of 23% of the area occupied by this seagrass on the northern coast of Catalonia is remarkably significant owing to its low recovery potential (very low growth rate). This study focused on the burial of shoots, but the effect of hydrodynamic forces ripping off shoots, which was not evaluated in this study, may also have been important. There were, however, large amounts of shoots washed up along the coast in the days immediately after the storm, which gives visible evidence that losses were greater than the ones reported here.

Acknowledgements

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