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Mortality and productivity of eelgrass
*Zostera marina* under conditions of experimental burial with two sediment types

Katherine E. Mills1*, Mark S. Fonseca2

1Department of Natural Resources, Cornell University, Ithaca, New York 14853, USA
2NOAA, National Ocean Service, Center for Coastal Fisheries and Habitat Research, 101 Pivers Island Road, Beaufort, North Carolina 28516, USA

ABSTRACT: Mortality and productivity of *Zostera marina* L. were assessed to examine the effects of experimental burial using 2 types of sediment: (1) sand (86% silt and 0.2% silt-clay and organic matter content, respectively), and (2) silt (27% and 3.3% silt-clay and organic matter content, respectively). *Z. marina* was buried to 0, 25, 50, 75, and 100% of its average aboveground height (16 cm) in an existing eelgrass bed using 2 types of sediment characterized as either silty or sandy. Increasing percent-ages of plant burial significantly increased mortality and decreased productivity. Survival and pro-ductivity of eelgrass were substantially reduced when only 25% of the plant height was buried. Plants buried 75% or more of their height were characterized by survival and productivity measures of 0. No statistically significant differences in plant mortality or productivity were found between the 2 sediment types in this experiment. Changes in morphology of the plants were shown to increase in size of leaf length and surface area in a short duration (12-4) trial of the experiment, apparently in response to senescence, but dilution was not observed. Results of this experiment indicate that *Z. marina* can only tolerate rapid sedimentation events that cover less than half of its photosynthetic surfaces. Furthermore, the lowest levels of burial treatments (25% of plant height) resulted in mor-tality greater than 50%, indicating that even this small level of rapid sedimentation is significantly detrimental to *Z. marina*.

KEY WORDS: Seagrass - *Zostera marina* - Mortality - Productivity - Burial - Deposition - Sediment type

INTRODUCTION

An important function of seagrasses is their ability to stabilize sediments of shallow marine areas (for a review see Fonseca 1996). Natural events such as storms can distribute sediment over plant surfaces. However, seagrass communities typically establish a long-term equilibrium that accommodates such events (Fonseca et al. 1986, Fonseca & Bell 1998). In addition, anthropogenic perturbations can increase the sediment load entering seagrass beds. Increased sediment loads in rivers due to upland runoff, trapping of material by beach stabilization projects, and dredging and/or dumping at dredged material or other examples of anthropogenic activities that may disrupt the equilibrium of the system and impose the condition of seag-grass plants (McRoy & Helfferich 1980, Shepard et al. 1989, Verrnaat et al. 1996, Diarte et al. 1997, Toccardo et al. 1998). In addition, vessel groundings (authors pers. obs.) and the activities of burrowing animals (Sucklemann 1983, Zebias et al. 1996, authors pers. obs.) often result in substantial displacement of sediment over adjacent seagrass areas.

Burial of seagrass decreases the available photosynthetic area of the plant and increases the respiratory demand of the buried portion. In addition, hypoxic conditions are likely to occur at some depth below the sediment surface in this area (Kenworthy et al. 1992). Burial rate (i.e., faster than a given species can alter its morphology to respond to changes

*Email: kem2@cornell.edu*
in sediment levels raises the sediment surface. The depth of sediment anoxia almost certainly rises upwards toward the photosynthetic portions of the sea-grass. These conditions may result in anoxia and associated associated problems in the root system and other newly buried tissues from the surrounding sediments (Goodman et al. 1996, Ver- meest et al. 1993). This situation may inhibit the plants' recovery from the burial event and create conditions under which the plants experience elevated physiological stress (Goodman et al. 1995), which if prolonged, could lead to death (McRoy & Heffernon 1989). How- ever, due to different resource allocation strategies and life history characteristics, sea-grasses species may vary in their tolerance of sedimentation events, and some species such as *Amphibolis griffithii* (authors' pers. obs.) may be specifically adapted to fluctuating sediment levels (Clark & Kuzman 1989, Prent et al. 1990, Duarte et al. 1997, Terrados et al. 1998).

However, to our knowledge, there have been no quantitative examinations of the tolerance of the North American sea-grasses to burial events. Therefore, to address this issue, we conducted a burial experiment on one of the dominant North American species, sea- grass *Zostera marina* L., in the North River estuary near Beaufort, North Carolina. In this experiment, we attempted to identify a threshold at which burial in- creased the likelihood of mortality or decreased pro- ductivity of *Z. marina*. When many scenarios may be envisaged that depend sediment onto sea-grasses, ranging from gradual (days to weeks) to rapid (hours to days), we chose to rapidly bury upright plants at a range of depths in an attempt to examine the immediate tolerance of these species to different levels of burial. Our study addresses changes in mortality and produc- tivity of sea-grasses caused by burial and increasing heights, thereby decreasing available photosynthetic surface area. We hypothesized that produc- tive capacity increases as a consequence of plant height due to a proportional reduction in the exposed leaf area able to photosynthesize. Beyond some level, burial was expected to prove fatal to the plant. Organic content of the sediment which is strongly correlated with particle size in our systems, contributes to a higher sulfide content which may fur- ther stress the plants (Kennedy et al. 1982, Carbon et al. 1994, Goodman et al. 1995). Therefore, to test the effect of varying levels of sediment composition on plant mortality and productivity, we buried plants in both silt and sand sediment types, where silt sedi- ments have naturally higher organic content. We ex- pected lower productivity and higher mortality for plants buried in silt sediment than those buried in sand. Finally, we anticipated the possibility of morpho- logical changes in the plants themselves caused either by etiolation (Marha & Duarte 1994) or determination as a response to burial. We hypothesized that should plants survive, they may show longer leaf and sheath lengths to a certain depth of burial, but that surface area would remain constant since the plants would be under poor conditions for increasing their total bio- mass.  

**MATERIALS AND METHODS**

**Experimental design.** Three species of sea-grass are found in estuarine areas near Beaufort, NC, during various times of the year. *Zostera marina* is near the southern limit of its Atlantic range in NC. It grows mainly between fall (October) and mid-summer (July) with its peak biomasses in early June (Kennedy et al. 1992, Uwayd et al. 1994). Its abundance rapidly declines with increasing water temperatures in August and September. During the time of this study, *Z. marina* was the only sea-grass species present at the study site. *Halodule wrightii* and *Ruppia maritima* begin growing in May, peak in biomass during late summer and decline in October (Thayer et al. 1984). A 5 x 12 m plot of an existing, quiescent eelgrass bed was chosen in the North River near Beaufort, NC (35°42' N, 76°36' W; reported as site 'ST' in previous studies. Murphy & Formosa 1985, Formosa & Bell 1998), within an area of unbroken eelgrass coverage at this site. This site receives mesotrophic to oligotrophic water with an average water temperature of 5.5 to 18°C and salinity measured 30% to 35 ppt during the course of the experiment. The area was divided into 3 blocks, each oriented in a cross-channel direction at a constant depth. Twelve treatments were assigned to each of the 3 blocks in a randomized complete block design. Treatment posi- tions were located 1 m apart within a block, with an additional space of 2 m between blocks. Two sediment types, sand and silt, were obtained from areas near the site. Sandy sediment consisted of 26% gravel, 3166% sand, 5.8% silt clay and 0.24% organic matter (OM). By comparison, sediment at the study site was composed of 0% gravel, 73.3% sand, 26.7% silt clay and 3.31% OM.

An arbitrary sample of plants in the study area indicated that the average height (from leaf blade) of *Zostera marina* at the time of this study was approximately 16 cm. Five burial treatments using each sedi- ment type were established based on this average overall height. Plants were buried to 0%, 25%, 50%, 6 cm, 12 cm and 0% of the average height. Burial treatments were conducted within 20 cm tall by 13.2 cm diameter polyvinylchloride (PVC) cylinders (Fig. 1). Cylinders were planted at a depth of -4 cm into the substrate, approximately to
the depth of the plant rhizomes. Care was taken not to
cover the rhizomes, however; we cannot ensure that
the rhizomes were not pushed slightly deeper into the
sediment in this process. Cylinders (used in sand to
a height of 16 cm and this portion remained fully
submerged at low tide. Cylinders without sediment
(0% fill) served as the sediment controls for the exper-
iment and were artificially assigned to either the sand
or the silt treatment group. Cylinder controls (un-
disturbed areas of the seagrass bed) were also established
within the block as a treatment to assess whether the
cylinders themselves had any effect on the
response of the seagrass.

One replicate of each burial treatment and 2 repli-
cates of the cylinder control were assigned within each
block. Three plants in each of the 36 total experimen-
tal units were uniquely tagged with numbered strips of
aluminum duct tape, and plants were marked using the
syringe hole punch technique described by Denio-
son (1998), as modified from Ziemann’s staple method
(Ziemann 1974). As cylinders were filled with sediment,
care was taken to ensure that blades were not broken
and that plants remained upright within the sediment
matrix. This experiment was conducted twice due to a fail-
ure of the sheath marking technique during the first
trial (Blocks 1: February 15 to March 10, 1996; Blocks 2
and 3: February 24 to March 20, 1995). A 29 gauge
needle was used to mark plants as the first trial, but
these small holes healed beyond recognition during the
course of the study. A larger, 26-gauge, needle was
used for the second trial (March 31 to April 13, 1995).
Although productivity could not be assessed during the
first trial (24 to 28 d), mortality calculations were
excessively obtained. The control, shorter trial (12 d)
was used to determine productivity differences among
the treatments. The shorter period of the second trial was
necessary because it was later in the year and produc-
tivity was expected to be higher. During the second
trial, 100% initial treatments of both sediment types
were eliminated because all plants subjected to this
burial died during the first trial and decomposed to
the point where they were barely identifiable as to
their parent source.

Seagrass analysis. Mortality: Mortality was deter-
mined for the first (24 to 28 d) trial of this experiment.
At the time of harvest, plants were considered to be
dead if they were completely black, disintegrating
and/or had not rigid rhizomes. Some plants showed
signs of stress, such as wilted leaves and black spots.
However, these plants were characterized as living,
particularly if the rhizome was still rigid, brightly snap-
ing when broken. Plants were not included in this anal-
ysis if their labels were not found at harvest. The
probability of mortality was calculated for each treat-
ment based on the total number of plants recovered at
the end of the experiment. Differences in mortality
with burial depth and sediment type were determined
using a logistic regression conducted with the logistic
procedure (SAS 1988). Cylinder control treatments
were included in this analysis as part of the 0% burial
category.

Productivity: Productivity analyses were conducted
for only the second (12 d) trial of this experiment.
The distance of new leaf growth for marked leaves, leaf
length, leaf length and dry weight were measured for
each plant harvested. In addition to length measure-
ments, the width of the second youngest leaf was
recorded to enable an approximate calculation of total
surface area of each plant. Dry weight was determined
after drying the plants to a constant weight approxi-
mately 74 h at 70°C.

Productivity was measured by developing a regress-
on equation to relate biomass of new leaves and their
surface area. Ten samples of leaf portions of varying
but known surface areas were randomly selected from
plants in this study. Sections were cut and dried to
a constant weight to determine biomass. New leaf growth
and plant width measured for all plants in this study
were used in this equation to estimate the change in
surface area during the course of the experiment. This
surface area change was then used in the regression
equation to determine the g of dry weight produced.

Productivity was calculated for plants that lived and
were recovered at the end of the second trial. The
effect of the experimental treatments on productivity
was analyzed with a 2-way ANOVA for a mixed design with 1 random factor (block) and 1 fixed factor (treatment). Grains dry weight (g dry wt) were square-root-transformed to meet the assumptions of least-squares analysis. Statistical analyses were conducted using the mixed procedure (SAS 1986). Linear contrasts were conducted to assess specific effects of interest.

**Morphological changes**: For the 12 d experiment, morphological features of plants were compared at the beginning (t1) and end (t2) of the experiment. Only plants that survived and were recovered at the end of the 12 d experiment were included in this analysis, since morphological features could not be measured for dead or decaying plants. Two plants with each 1 m² treatment were randomly taken at the beginning of the experiment, and shoot and leaf length sum of the 3 oldest leaves of each plant were determined in the laboratory. The same measurements as well as plant width were taken for plants from the experimental treatment at the end of the 12 d experiment. Surface area was calculated for plants at t1 and t2. Leaf length, shoot length and surface area were compared at t1 versus t2 using a 1-way ANOVA for each factor. Data from the normal linear model procedure (SAS 1986). For this analysis, leaf length and surface area were calculated based on the oldest 3 leaves of the plant, and only those leaves were measured on the L. plants.

**RESULTS**

**Mortality**

Data from the first trial of the experiment were used to determine the probability and likelihood of mortality for Zostera marina under varying lengths of burial in the 2 sediment treatments. Ninety-two plants of the 188 originally marked were included in this analysis. The remaining plants could not be found and were therefore left out of the analysis. Of the 92 recovered plants, 36 died during the course of this trial and 34 survived.

**Fig. 2** shows the probability of mortality for plants buried to varying levels in 2 sediment types. At a burial depth as low as 25% of the average above-ground plant height (d cm), the probability of mortality exceeded 50% in both sediment types. The probability of mortality increased rapidly when burial was 50% of plant height or more. At this depth, all of the plants in silt sediment were recovered and found to be dead. However, at 50% burial in sand, only 3 of the 5 plants in the treatment were recovered, and 2 were found to be alive (Table 1). Thus, the probability of mortality dropped below 50% for the sand treatment. Although we cannot know for certain, it is possible that some of the 4 plants that were not recovered may have been dead, and the low mortality rate shown in this treatment may simply be an artifact of the lesser recovery of plants. Nonetheless, mortality probability, weighted for the number of plants recovered in each treatment and combined across treatment types, shows a clear and sharp increase with burial depth. Combined mortality probabilities of at least 75% were shown for burial at 25 and 30% of plant height, and the probability of mortality reached 100% for burial at and above 75% of the plant height.

**Table 1.** Zostera marina. Number of plants in each treatment that were dead, alive or not recovered at the end of the 24 d experiment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number dead</th>
<th>Number alive</th>
<th>Not recovered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder control</td>
<td>11</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>0% sand</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>0% silt</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>25% sand</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>25% silt</td>
<td>6</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>50% sand</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>50% silt</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>75% sand</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>75% silt</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100% sand</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100% silt</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
The likelihood of plant mortality was modeled by the logistic regression equation:

$$\ln \left( \frac{p_{0}}{1 - p_{0}} \right) = -2.5891 + (0.1048 \times \text{sediment depth})$$

The model achieved a high goodness of fit ($p < 0.0001$) and analysis showed a significant effect of increased sediment depth on the likelihood of plant mortality ($p < 0.0001$) (Table 2). As shown in Table 2, for each incremental increase in burial level, the average odds of plant mortality increased by 3.131. As indicated in Fig. 2, the probability of mortality for plants buried in soil (overall $p_{0} = 0.967$) was slightly higher than for plants in sand (overall $p_{0} = 0.644$). However, the logistic regression analysis indicated that sediment type did not make a statistically significant contribution to the likelihood of plant mortality; near-shore sediments of sediment type as a covariate significantly improve model fit.

### Table 2. Zostera marina: Significance and effects on model fit of sediment depth and type in binary logistic regression model of $Z$. marina mortality. LR, residual log likelihood.

<table>
<thead>
<tr>
<th>Sediment depth</th>
<th>$p_{0}$</th>
<th>Odds ratio</th>
<th>$p$-value</th>
<th>$p$-value of model</th>
<th>$p$-value of residual log likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.2415</td>
<td>&lt;0.0001</td>
<td>1.131</td>
<td>1</td>
<td>$&lt;$0.0001</td>
<td>1.948</td>
</tr>
<tr>
<td>1.5346</td>
<td>0.0073</td>
<td>1.194</td>
<td>1</td>
<td>0.2953</td>
<td>1.654</td>
</tr>
</tbody>
</table>

(The 3) This equation was used to calculate primary production of the seagrass plants in terms of g dry weight during this experiment.

In this study, burial in either sediment type reduced productivity of $Z$. marina, and increasing densities of burial resulted in related reductions in plant productivity as well (Table 3). Measures of productivity as g dry weight for each surviving treatment are shown in Fig. 4. Some plants were dead at harvest, e.g. 75% burial (treatments) were either dead or not measurable. We cannot explain the death of all plants in the 0% soil treatment, particularly since these survived in the previous mortality experiment. However, in related reductions in plant productivity as well (Table 3). Measures of productivity as g dry weight for each surviving treatment are shown in Fig. 4. Some plants were dead at harvest, e.g. 75% burial treatments were either dead or not measurable. We cannot explain the death of all plants in the 0% soil treatment, particularly since these survived in the previous mortality experiment. However,

### Table 3. Zostera marina: Mean and SD for productivity in dry wt. of $Z$. marina buried to different proportions of total plant height in soil and sandy sediment.

<table>
<thead>
<tr>
<th>Sediment type</th>
<th>Mean dry wt (g)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.0526</td>
<td>0.0667</td>
</tr>
<tr>
<td>Sand</td>
<td>0.0256</td>
<td>0.0548</td>
</tr>
<tr>
<td>Soil</td>
<td>0.0256</td>
<td>0.0548</td>
</tr>
<tr>
<td>Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td>0.0123</td>
<td>0.0531</td>
</tr>
<tr>
<td>25%</td>
<td>0.0123</td>
<td>0.0531</td>
</tr>
<tr>
<td>75%</td>
<td>0.0123</td>
<td>0.0531</td>
</tr>
</tbody>
</table>

(Fig. 5) This equation was used to calculate primary production of the seagrass plants in terms of g dry weight during this experiment.

The equation, dry wt $= (12.27 \times 10^{-6} \times \text{cm$^2$ biomass area}) + (-6.921 \times 10^{-3})$, was found to relate biomass and surface area of plants in this experiment ($r = 0.67$)

![Graph showing relationship between biomass and surface area of plants.](image)

(Fig. 5) Zostera marina: Regression of surface area (cm$^2$) to biomass (g). • Show actual measurements of 11 plants. Solid line represents the binary regression equation to present biomass based on surface area ($r = 0.67$)

(Fig. 4) Zostera marina: Productivity (g dry wt) for each level and type (SA, sand; SI, soil) of burial treatment. Graph shows mean (g dry wt) and 1 SD from the mean for each treatment in which plants survived and were measured. Letters associated with each treatment indicate significant differences between the means for each treatment as shown by Duncan's multiple range test (SAS 1986).

![Graph showing productivity vs. burial treatment.](image)
these plants were excluded from statistical analyses, which makes our conclusions more conservative. Patterns in mean productivity of other treatments show a decrease in productivity with burial greater than 25% of plant height. At 75% burial, plants died even within the 12 d duration of this second trial. Biological analyses of productivity were conducted for only the plants that survived and were recovered at the end of this experiment. The effects of block and block by treatment were not significant, therefore, the reduced model that included only treatment effects was used for further data interpretations and reporting. Productivity varied significantly between treatments in this experiment (F = 3.21, df = 5, p = 0.028). A significant difference in productivity was evident for differences in the level of burial (t = 2.97, p = 0.006). However, no significant differences were attributable to sediment types (t = 0.58, p = 0.632). Thus, there was no evidence that particle size or organic content of the sediment affected plant productivity. This indicates that the depth of burial is driving the significant difference noted in productivity between treatments. Burial at depths greater than 25% of the plant height caused productivity to decrease regardless of sediment type.

Morphology

Plants subjected to burial treatments showed morphological differences from naturally occurring plants in the same area during the course of this study. Due to the observation of eminuliation as a response to burial in other seagrass species (Merha & Duarte 1994), we anticipated that total surface area of plants subjected to burial would remain constant, while leaf and sheath length may increase i.e. plants may grow longer while sacrificing width in an effort to increase the portion of leaves above the buried area. However, our results do not support this hypothetical response to burial.

We compared total leaf length, sheath length and surface area of a random sample of plants at the beginning and buried plants at the end of the 12 d experiment (Table 4). Sheath length did not show a significant difference over that time. However, leaf length and surface area were substantially lower in plants that endured the burial treatments (Table 5). This provides further evidence that burial may inhibit plant growth even over a short duration. The fact that leaf length decreased suggests that, in this setting, eminuliation may not provide a compensatory response to burial. However, it is important to note that the r' values of the fit of the loess-squares model was low for all of these tests. Thus, further studies through longer-duration experiments may be necessary to fully understand morphological responses of Zostera marina that survived partial burial.

**DISCUSSION**

The results of this study demonstrate the increased likelihood of mortality and decreased productivity of Zostera marina under burial conditions. Effects on plant mortality are associated with the depth of burial, but are not strongly influenced by the type of sediment in which plants are buried. Burial to depths as low as 25% of the aboveground plant height substantially increased mortality, with burial at this level causing the death of >75% of the plants. It appears that the threshold level of burial tolerance for Z. marina is extremely low. The mortality probability reached 100% between burial depths of 30 to 75% of plant height, depending on the type of sediment in which plants were buried.

Trends in productivity results were less dramatic than those for mortality. Ignoring the effect of sediment type, all treatments with burial of 30% plant height or greater had significantly lower productivity than the controls. At 75% burial, plants died and productivity was 0. Growth of other seagrass species can be enhanced under low levels of sedimentation or burial (Gallegos et al. 1983, Marha & Duarte 1994), and some species such as Amphibolis griffithii may be specifically adapted to periodic burial (authors’ pers. obs.) however, in our study, burial even at low levels did not increase growth of Zostera marina. The plants did
show a slightly higher productivity in the 25% sand treatment, but this did not differ significantly from the controls. Conversely, the 25% silt treatment reduced plant productivity.

For both mortality and productivity, sediment depth contributed significantly to the observed effects, whereas sediment type did not contribute significantly to the response. We posited that survival and growth would be higher in sand than in silt. The silt sediment with its higher organic matter content has been associated with less oxygen and stronger reducing conditions in the sediment (Kenworthy et al. 1982). Without sufficient oxygen supply for the plants, sulfide intrusion of their roots may occur (Caffarra et al. 1994; Goodman et al. 1995). From our short study, however, it appears that the physical and chemical properties of sediment as assessed via our experimental manipulation do not mediate the overall effect of burial on plant mortality and productivity. Burial contributed to reduced productivity and increased mortality of Zostera marina, and this main effect was not significantly influenced by different sediment types used in our study. Effects due to sediment type may be masked by the relatively short duration of our experiments and may have become evident if studies were continued for a longer time. The first-order main-effects response clearly relates to sample extent of burial; however, concentrations of organic matter higher than those tested here or longer exposures to oxic sediments at reduced levels of burial may contribute further to the demise of Z. marina plants.

Changes in leaf length and surface area of the plants were noted during the course of this study. We anticipated that plants may show evidence of etiolation as observed in previous studies with other species (Martha & Bourne 1984). Thus, we expected an increase in leaf length as plants respond with growth that moves photosynthetic surfaces above the burial interface. Through etiolation, it was expected that width would be sacrificed to enhance length and that total surface area would remain constant. Indeed, plants subjected to burial treatments were significantly shorter in length and smaller in surface area than unburied plants, which was consistent with our observations of their senescence. This may indicate that even low levels of sedimentation may inhibit the plants' ability to respond quickly in a compensatory manner. However, the short duration of this study may not have provided sufficient time for plants to redirect their growth energy in response to sedimentation. A longer study under low light conditions of burial may be necessary to fully understand the morphological changes of plants as non-etiolated responses to sedimentation.

One may anticipate several detrimental effects of acute sedimentation in seagrass beds, such as complete burial and breakdown of plants. However, this study attempted to simulate sedimentation events that allow plants to remain standing in the water column such as might be expected when heavy loads of suspended sediment settle out of the water column or sediments settle into a bed with storm events. Our results indicate that even more gradual sedimentation events, occurring over several days, that do not otherwise damage the plant structure can pose substantial threats to the survival and growth of seagrasses. Regardless of the form of sedimentation, Zostera marina appears to be sensitive to burial compared with other species in the Mediterranean (Posidonia oceanica) and Australia (Amphibolus griffithii) (Van Raad et al. 1986, authors' pers. obs.). Exposing even a small portion of Z. marina's photosynthetic surface substantially increases mortality and decreases productivity. Activities in and adjacent to Z. marina beds and, potentially, seagrass species with similar morphology and growth strategies, should be carefully planned to minimize sediment disturbance, suspension of particles that may settle out on the plants and instillation of bulk sediment into the habitat.

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LITERATURE CITED


