Hydrodynamic Exposure Affects Sea Grass Stocks in the Wadden Sea

Anja Schanz, Alfred-Wegener-Institute, List/Sylt, FRG

Introduction

Sea grass beds are of a high ecological importance for the coastal ecosystem of the Wadden Sea. The complex canopy structure fishes and crustaceans. In addition, sea grass beds improve the water quality by filtering suspended matter and act as a sink for nutrients. The sea grass roots- and rhizome systems bind and stabilize the sediment, thus counteracting erosion processes. As sea grasses require a high quality of environmental conditions, they respond very sensitively to changes in their environment. Thus sea grass beds are suitable indicator communities for the health and stability of coastal ecosystems.

Since intertidal sea grasses, *Zostera marina* and *Z. noltii*, have continued to decline in the Wadden Sea since the early 1970s, sea grass deterioration is attributed to human induced disturbances and climatic changes. Eutrophication enhanced water turbidity and the growth of algae, which are harmful for the health of sea grasses. In addition fishery using dredges and land reclamations are recorded to damage sea grass stocks. Long-term observations in the Wadden Sea revealed that hydrodynamics gradually increased during the last century. A combination of coastal engineering, as for example the construction of dikes and connecting dams, and a rise in sea level led to increasing erosion processes and drastic losses of shore biotopes and epibenthic communities, especially sea grass stands during the last decades (Reise et al. 1998).

However, whereas in the western and central Wadden Sea sea grass loss is ongoing, sea grass stocks in the northern Wadden Sea remained comparably stable and unaffected (with annual fluctuations). At present intertidal sea grass stocks, dominated by *Z. noltii*, are covering approximately 60 km² of the entire Wadden Sea. Thereof more than 90 % of sea grasses are situated in the northern part of the Wadden Sea (Reise 2003). These sea grass beds are generally distributed on the sheltered sides of the islands and behind higher sands, where they grow protected from higher water dynamics caused by prevailing westerly winds. Based on these observations, it is assumed that hydrodynamic exposure has an impact on the development of sea grass.

Impact of Hydrodynamics on *Zostera noltii*-beds

To investigate the impact of hydrodynamic exposure, such as high tidal currents and wind waves on the development and structure of intertidal sea grass beds, two *Z. noltii* stocks with different hydrodynamic exposure were investigated on the tidal flats near the island of Sylt (Sylt-Rømø Bight, northern German Wadden Sea) (Fig. 1) from 1997 to 1999. An exposed sea grass site near a deep tidal channel with maximum current velocities up to 33 cm per second was compared with a sheltered sea grass bed which was protected by the island from prevailing westerly winds and stronger currents. Here current velocities were only half of those values measured at the exposed site. Conspicuously, the sea grass cover was dense at the sheltered site, whereas at the exposed area sea grass cover was comparably sparse. In addition exposed sea grass leaves were heavily overgrown with epiphytes, which are known to inhibit sea grass growth due to shading and nutrient competition. However, the layer of epiphytes on exposed sea grass plants is a result from strong currents, promoting fouling on sea grass leaves by reducing the density of grazers, as has been shown in a previous study (Schanz et al. 2002).

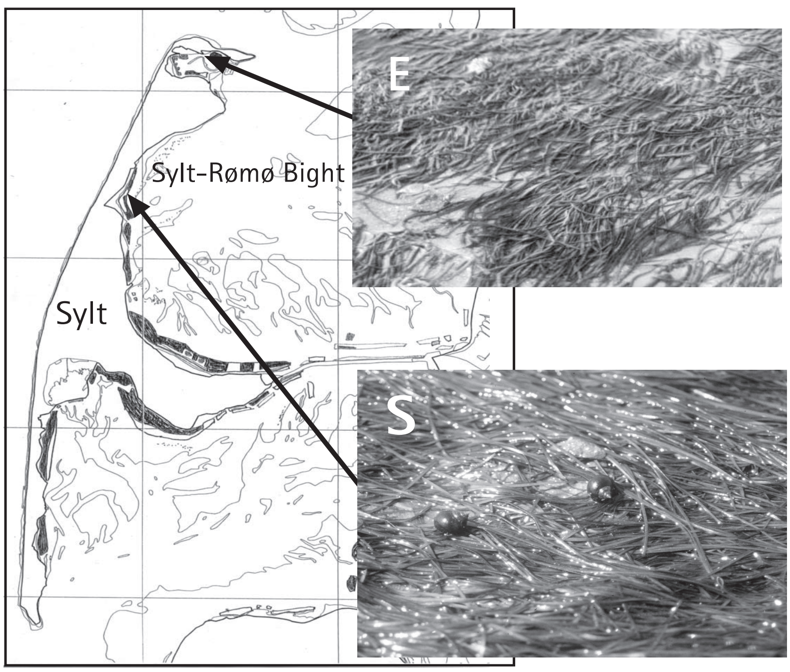

Figure 1: Distribution of intertidal seagrass beds (shading) on the tidal flats near the island of Sylt. Arrows indicate the investigated hydrodynamically exposed (E) and sheltered (S) *Zostera noltii* sites in the Sylt-Rømø Bight.

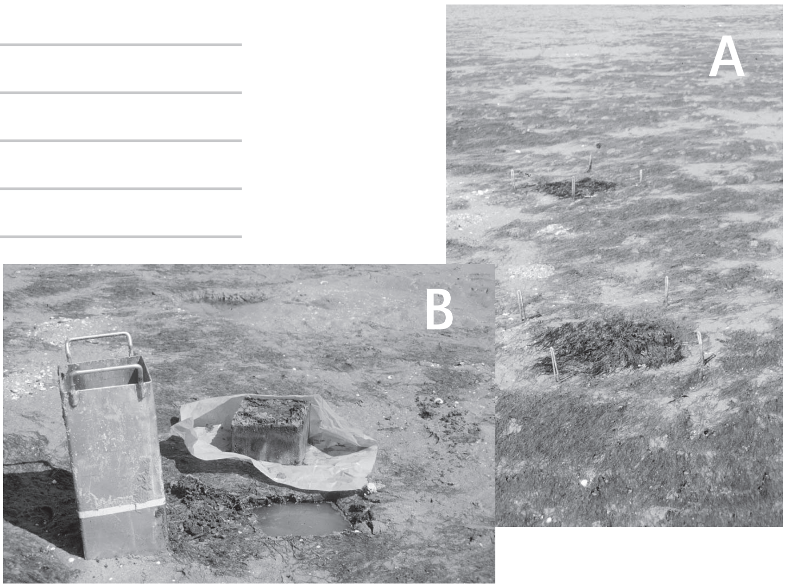

Figure 2: Transplantation of seagrass sods. A: Two replicate seagrass sections, freshly transplanted from sheltered into the exposed bed. B: Seagrass sod, freshly taken by using a box corer.

To compare both sea grass sites, the density and biomass as well as the shoot morphology of *Z. noltii* was estimated at times with highest sea grass density in August and September 1997, 1998 and 1999. The investigations showed that sea grass density and biomass were distinctly higher in sheltered areas, whereas at exposed sites, sea grass beds occurred only sparsely with a comparably low biomass during the whole study period. In addition the plant length and the leaf length were distinctly higher at sheltered sites than in exposed beds.

Transplantation Experiments

To test whether hydrodynamics influence sea grass development and plant morphology, cross transplantation experiments of sheltered and exposed sea grass sods were carried out at the end of July 1999. 4 sea grass sods, comprising one replicate test section (2000 cm²) were carefully taken from each site by pushing a box corer into the sediment (Fig. 2). 6 replicate sea grass sections from each site were exchanged by 6 sea grass sections from the other site. As a result of this experiment the initial plant density as well as the shoot and the leaf length were drastically reduced by more than 70% after transplantation of sheltered sea grasses into the exposed area, and were even lower than sea grass values of the adjacent sea grass after 6 weeks. In contrast, the sea grass density as well as the length of shoots and leaves distinctly increased after transplantation of exposed sea grasses into a sheltered bed.

Field Flume Experiment

By means of an *in situ* "three-currents-flume" the direct impact of modified current velocities on sea grass bed structure was quantified experimentally at the same habitat conditions. The flume consisted of a heavy steel frame with flexible walls of textile awning forming nine lanes (7 m long, 12 m wide, 1 m high) (Fig. 3). At the beginning of April 1999, the flume was placed in the sheltered sea

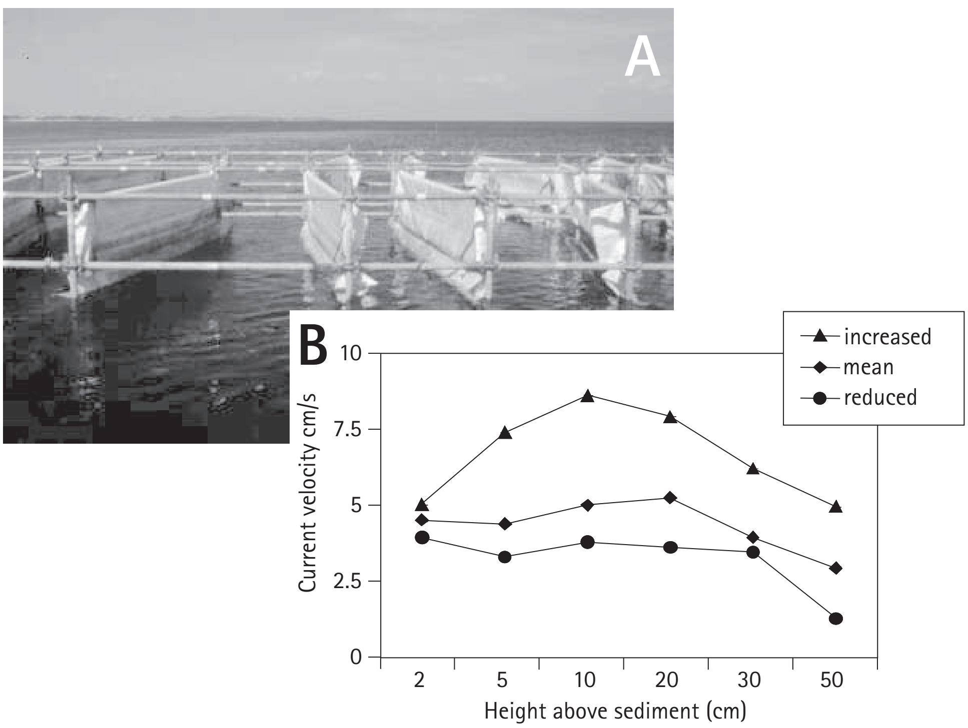

Figure 3: "Three-current-flume" at high tide. A: Close-up view of three flume lanes with differently modified current velocities in the mid section of the lanes. B: Mean current velocity measured within the differently modified flume lanes with increased, nearly unaltered and reduced current flow.

grass bed aligned with the prevailing flow direction (allowing a bi-directional current regime). By modifying the channel openings, this system either increased (broad opening of the lane), let nearly unaltered (parallel walls along its total length) or reduces (central widening of lane) tidal current velocities in the mid-section of the lanes relative to ambient current velocities outside the flume. Each flow treatment consisted of three replicates. The plant density and plant morphology within the different lanes of the flume were recorded in August and September 1999. The flume experiments showed that the density as well as the shoot and leaf length of *Z. noltii* decreased distinctly with increasing currents within the different lanes (Fig. 4), despite growing under the same habitat conditions.

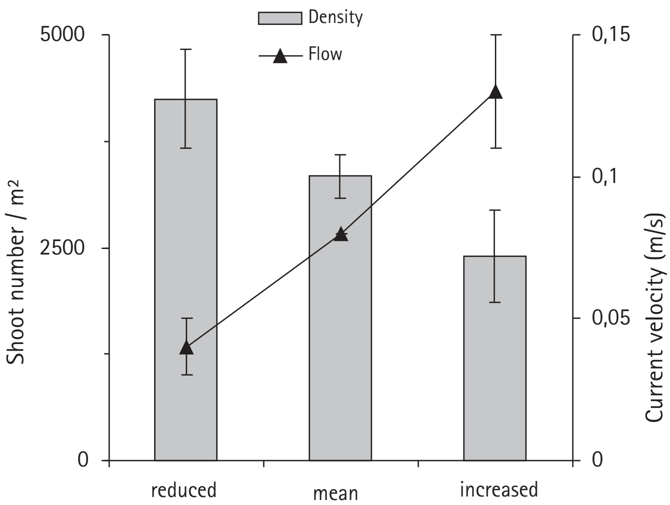

Figure 4: Effect of reduced-, mean- and increased flow treatments within the "three-current-flume". Seagrass density decreased with increasing current velocities.

Conclusions

The comparison of different sea grass sites in the Sylt-Rømø Bight as well as the field experiments indicate that strong hydrodynamics directly affect the development and structure of *Z. noltii* beds by reducing the sea grass density and shoot morphology. In addition, the results of a previous study revealed that increasing hydrodynamics indirectly impact sea grass development, by reducing the density of grazers, thereby inducing a higher vulnerability of sea grass due to enhanced fouling.

The results of this study might contribute to explain the spatial pattern of sea grass losses in the Wadden Sea, as sea grasses in the western and central Wadden Sea are rather unprotected and exposed to comparably higher tidal current velocities (except within sheltered bights as in the Jadebusen and the western estuary of the Weser) than sea grasses in the northern Wadden Sea. Thus since changes in environmental conditions are ongoing (e.g. higher storm frequency rise in sea level in combination with man-made protective constructions, such as dikes and dams etc.), it is suspected that increasing hydrodynamics might contribute to losses of intertidal sea grass beds.

References

Reise K., Herre E. Sturm M, 1998. Historical changes in the benthos of the Wadden Sea around the island of Sylt in the North Sea. Helgol. Meeresunters. 43, 417-433.

Reise K., 2003. Grüner Wechsel im Wattenmeer: Weniger Seegraswiesen und das Aufkommen der Grünalgenmatten. In: Lozán J.L., Rachor E., Reise K., Sündermann J., von Westernhagen H. (eds.) Warnsignale aus der Nordsee & Wattenmeer – Eine aktuelle Umweltbilanz, pp 196-200.

Schanz A., Polte P., Asmus H., 2002. Cascading effects of hydrodynamics on an epiphytegrazer system in intertidal sea grass beds of the Wadden Sea. Mar. Biol. 141, 287-297.

Anja Schanz
Stiftung Alfred-Wegener-Institut für Polar- und Meeresforschung, Wattenmeerstation Sylt
Hafenstrasse 43
D-25992 List
aschanz@awi-bremerhaven.de