The influence of Zostera spp. on sediment habitat in the Tay estuary, Scotland.

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Introduction

The Tay estuary, on the east coast of Scotland is a special area of conservation (SAC) and contains a number of priority habitats including saltmarsh and beds of the intertidal seagrasses Zostera angustifolia and Z. noltii. In Britain 25% of our natural intertidal areas, including saltmarsh, have been lost in the last century. The areas of saltmarsh at Tayport and Tentsmuir are decreasing as the seaward edge is eroded, and internal dissection of the marshes is also evident. In terms of seagrasses, the three species of Zostera found in the UK are scarce and there has been a continual decline in populations since the 1960s, and this is also true of the Tay Estuary. As well as providing habitat, protection and food for flora and fauna, seagrasses stabilise sediments, trap fine-grained suspended particles, and elevate the bed by raising the sediment surface. On the upper shore this may lead to saltmarsh succession (Figure 1). Saltmarsh protects the coastline from scour and wave erosion by dissipating the energy of tidal currents and waves.

The IPCC predict more frequent coastal flooding and increased erosion, due to storms and sea-level rise. The rate of coastline regression and sediment erosion is predicted to be ~6 m yr\(^{-1}\), and in estuaries, sea level rise will cause greater seawater intrusion inland. However, the predicted rise of sea level is within the vertical growth rate of most seagrass species, and seagrass canopies may be able to survive at relatively similar depths for some time.

This PhD project will provide an insight into the ecology of eelgrass in the Tay estuary and its role as an ecosystem modifier. It may offer valuable data in terms of seagrass conservation, for example, contributing towards future monitoring, and to transplantation trials.

Project aims

• To carry out a full survey of Zostera spp. to determine its distribution in the Tay estuary.
• To carry out an ecological study of Z. angustifolia and Z. noltii communities to investigate whether their distribution could be greater where suitable sediments may be present.
• To investigate the effects of Zostera spp. on sediment deposition and resuspension.
• To investigate the role of Zostera noltii as a pioneer species, leading to saltmarsh succession.

Methods

• A survey of eelgrass distribution was carried out in the intertidal zones of the outer Tay estuary, followed by detailed mapping of the location and density of eelgrass beds.
• Sampling took place in and around six eelgrass beds, two of Z. angustifolia and four of Z. noltii, at Tayport to compare the biological, physical and chemical characteristics of sediment where eelgrass grows and bare sediment. Sediment was analysed for water content, organic concentration and grain size distribution. Analysis of sediment colloidal-S carbohydrate concentration and chlorophyll concentration will also be carried out. Salinity, redox and dissolved oxygen were measured. Pore water samples were taken to determine NO\(_3\)-N, NH\(_4\)-N and PO\(_4\)-P content. Macrofauna cores were also taken.
• Using a flume tank (Figure 2), fluorescent magnetic tracer particles were used to quantify the rate at which suspended sestonic particles are retained by Z. noltii beds, and to explore how different sized particles were trapped. Treatments comprised intact samples of sediment taken from the estuary with low (200 m\(^2\)), medium (600 m\(^2\)) and high (1000 m\(^2\)) densities of eelgrass, and of bare sediment. The effects of current speed on bed shear stress and sediment accretion were also examined.

Results

• Beds and patches of Z. angustifolia (~1 ha) and Z. noltii (~3 ha) were found only on mudflats near Tayport. Z. noltii was present at the upper shore levels while the densest beds of Z. angustifolia were found on the lower shore. The map (Figure 3) gives an indication of the distribution and density of the two species.
• Sediment redox potential was lower in vegetated patches than in bare patches (p <0.02). No significant differences were found between vegetated and bare patches, or between beds, for pore water content and salinity, dissolved oxygen.
• Z. noltii beds had smaller particles, higher organic matter content and lower pore water NO\(_3\)-N, NH\(_4\)-N and PO\(_4\)-P compared to Z. angustifolia beds, but no differences in these parameters were seen between vegetated and bare sediments.
• Shoot density had a highly significant effect on bed shear stress at low (0.04 m-s\(^{-1}\)), medium (0.15 m-s\(^{-1}\)) and high (0.4 m-s\(^{-1}\)) current velocities (p <0.05) (Figure 4). As velocity and shoot density increased the frictional force exerted on the bed increased. However, at low, medium and high velocities, flow within the bed decreases with increasing shoot density.

Future work

• Continuing analysis of sediment, pore water and macrofauna samples, with comparisons to other estuaries.
• An in situ experiment focusing on the role of Z. noltii in decreasing sediment resuspension.
• The use of natural and artificial eelgrass beds to encourage sediment deposition and saltmarsh succession will be explored. The use of transplanted turfs of Z. noltii will also be tested.

Figure 1. The intertidal seagrass species Zostera noltii increases sediment deposition and decreases resuspension, elevating the sediment surface and allowing successional saltmarsh plants such as Scirpus maritimus to establish.

Figure 2. a) The flume tank at the Gatty Marine Laboratory, University of St Andrews; b) measuring water flow through an eelgrass bed in the flume using an Acoustic Doppler Velocimeter; and c) fluorescent particles adsorbed to the leaf surface of Z. noltii and trapped by epibionts.

Figure 3. The distribution of Zostera noltii and Z. angustifolia at Tayport in the Tay estuary, Scotland, July 2008, and patch numbers for sampling.

Figure 4. a) Bed shear stress increases with increasing shoot density at low, medium and high velocities; and b) flow profiles of bare sediment, low, medium and high density Zostera noltii at 0.15-0.17 m\(^{2}\) flow.

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