TIDAL MARSH MODELLING IN THE SCHELDT ESTUARY:
DETERMINE RESTORATION POTENTIALS FOR MANAGED
REALIGNMENTS
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Abstract: The River Scheldt is a macrotidal estuary with a tidal reach up to 160km upstream and a complete salinity
gradient including polyhaline to fresh water habitats. The estuary has been heavily impacted by anthropogenic
pressures such as land reclamation, harbour expansion, dredging activities, embankments and urbanisation. As a
consequence tidal mudflats and marshes deteriorate or disappear by erosion or submersion.

In the updated SIGMAplan 1400 hectares of managed realignments are planned along the whole salinity gradient to
reinstate and strengthen the ecological functioning in the Scheldt estuary. Restoration sites are located according to
the estimated potential for tidal energy dissipation and nutrient (re)cycling. In order to predict development of tidal
marsh habitats after implementation of the restoration measures the link between (a)biotic factors and habitat
development in the current situation was investigated. Salinity and surface elevation in relation to tidal inundation
regime (inundation frequency and duration) are the main key factors that determine the potential for tidal marsh
development, provided that surface area, shape index and overall slope of the site are favourable. Also management
and biotic factors such as occurrence of more competitive species influence the present habitat distribution and
species presence in tidal marshes of the Scheldt estuary.

Based on the main drivers, a predictive model for potential habitat development and species presence in the new
restoration areas is made for the different salinity zones and tidal tributaries of the Scheldt estuary. With these models
the potentials for tidal marsh development in new de-embankments for the whole Scheldt estuary can be predicted,
including Natura-2000 habitats of the Atlantic salt marshes and meadows (13) and Hydrophilous tall herb fringe
communities of plains and of the montane to alpine levels (6430).

Keywords: 1130 Estuaries, 13. Atlantic and continental salt marshes and salt meadows, restoration of water
dynamics, managed realignment, tidal marsh restoration, 6430 Hydrophilous tall herb fringe communities of plains
and of the montane to alpine levels

Introduction
The River Scheldt is a macrotidal estuary with a tidal reach up to 160km upstream from the
mouth near Vlissingen (The Netherlands) to Ghent (Belgium). The mean tidal amplitude
increases from 3.9m at Vlissingen to 5m near the border and 5.5m near Temse. Further
upstream it reduces to 2.4m in Melle. The river discharge varies from 53m³ s⁻¹ during summer
to 316m³ s⁻¹ during winter, with a mean yearly average of 147m³ s⁻¹. (period 99-04, data FHR).
The surface of the lower and middle estuary (Wester schelde) amounts to 310 km², with the
tidal marsh area covering 9%. Here a multiple channel system exists with an average channel
depth of 15 to 20m. In the upstream part of the Dutch/Belgian border the estuary is
characterised by a single channel with a depth of 15 to 3m. This upper estuary, including tidal
tributaries, covers 55km² has a storage width between 1km and 96m between the dikes. The
tidal marsh area in the upper estuary covers 10% or 595 ha. Along the Rupel tidal tributary
there are 39ha of tidal marshes (16% ) and 105 along the narrow tidal tributary of the Durme.

The estuary has been heavily impacted by anthropogenic pressures such as land reclamation,
harbour expansion, dredging activities, embankments and urbanisation resulting in a decrease
of tidal mudflats and marshes from 2500ha in 1850 to the present 1100ha in the Belgian part
and from 17000ha to 11000ha in the Dutch part (Van Braeckel et al. 2006, Van den Bergh et
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In the last decades tidal mudflats and marshes deteriorate or disappear by erosion or submersion under the increased hydromorphological pressure.

Together with the third deepening of the Scheldt navigation channel, dike fortifications and additional Flood Control Areas (FCA), 989ha of managed realignments and 759ha of flood control areas under controled reduced tide (FCA-CRT) are planned in the Belgian part of the estuary with the projects of the Long Term Vision for the Scheldt estuary (LTVS), the updated Sigmaplan and the strategic planning of the Antwerp harbour (figure 1). Together with the planned 379ha managed realignments in the Dutch part these new tidal wetlands should reinstate and strengthen the ecological functioning of the Scheldt estuary. These restoration sites are located along the complete salinity gradient according to the estimated potential for tidal energy dissipation and nutrient (re)cycling. In order to predict development of tidal marsh habitats after implementation of the restoration measures the relation between (a)biotic factors and habitat development in the current situation is investigated.

Figure 1. a. Paardeshor, a recent managed realignment site in the brackish zone with pioneering Aster maritimus vegetation, b. planned managed realignments (MR) and flood control areas under controlled reduced tide (CRT) along the Scheldt estuary

Materials and methods

To determine the potential for tidal marsh development, plant species groups are related to the primary key factors salinity and tidal regime.

A first aspect is the longitudinal species groups distribution, characterised by the most dominant species, along the complete salinity gradient. For this analysis the salinity gradient is categorized in 20 OMES-zones based on modelled residence time of chloride ions representing zonation along the salinity gradient (figure 3a, Soetaert & Herman 1995).

A second aspect is the vertical species group distribution in the Scheldt Estuary. As input data we use vegetation maps covering the whole study area. The frequency distribution of different plant species groups is analysed in relation to different tidal parameters, such as inundation frequency and duration. The relative position in tidal frame was determined with the mean high water level (MHW) for the period 1998-2000 as reference level along the whole Scheldt estuary and its tidal tributaries. The topographic elevation data is deduced from a digital terrain model with a 2x2m grid.

Habitat potentials after restoration are derived from present relations and distributions of species on existing tidal marshes along the Scheldt estuary. This large scale approach does not
take into account differences in plant dispersal, small scale processes or the geomorphological characteristics of the restoration sites (e.g. surface area, shape index and overall slope) which are very important in new managed realignment sites.

Results and discussion

The salinity gradient of the Scheldt estuary results in a diversity of habitat potentials. Generally we found an increase in plant species groups in downstream-direction (figure 2). The composition changes from typical haline species groups in the salt and brackish zone, to fresh water species in the upstream part of the estuary. In the zone with a high salinity variability upstream the Dutch-Belgian border the species group composition shows a strong shift from haline dominance to fresh water species dominance.

![Figure 2. Number of plant species groups along the salinity gradient](image)

Not only the species composition changes along the salinity gradient but also the relative position of one single species within the tidal frame shows a shift. For example the vertical distribution of Sea club-rush (*Scirpus maritimus*), a typical brackish species group, moves to lower levels in the tidal frame upstreams direction in the mesohaline tidal marshes (figure 3b).

![Figure 3. a Salinity & Omes zones, b Vertical distribution shift of Sea club-rush along the salinity gradient.](image)
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To assess potentials for tidal marsh creation it is of major importance to consider these salinity and tidal elevation (or inundation frequency-IF) gradients. Based on the present topographic elevation of the planned managed realignment sites initial habitat potentials are merely situated in the pioneer zone of the tidal marsh evolution of the Scheldt estuary. Many parts will even develop into tidal mudflats in initial stages. With adapted restoration design net sedimentation and progressive succession in the restoration sites can be enhanced or delayed, according to the restoration goals.

In the zone with a strong salinity gradient (omeszone 9) only the higher part of the Hedwiegspolder can have tidal marsh development in the planned managed realignment site near the Dutch-Belgian border (MHW:5.2 m, elevation: min.1.9 –avg.4.3-max.5.2). In the low pioneer zone (IF:>99%, 2m-4m TAW) there is a high potential for Spartina townsedonia and if salinity is high enough also Salicornia spec. Vegetations dominated by Glaux maritima, Scirpus maritimus and Aster tripolium can develop in the high pioneer zone (IF:99.50%,4m-5m20 TAW). The lowest areas will initially develop into tidal mudflats.

In the fresh water zone the managed realignments Groot Schoor (omeszone 15, MHW:5.5 m, elevation: min.4.1m, avg.5.0m, max.5.6m) and Uiterdijk (omeszone16, MHW:5.1 m, elevation:min. 4.4m,avg.4.8m, max.5.3m) show initial potentials for Scirpus maritimus, Scirpus triqueter-group and Lythrum salicaria dominance in low pioneer zone( IF:>99.7%, 2m -4,3m). In the high pioneer zone (IF:99.7–60%, 4.3-5.5m TAW) there is potentials for the Polygonum hydropiper-group and for dominance of Epilobium hirsutum. Based on the present distribution of species groeps in the Durme the potentials for e.g. the Groot Broek site (MHW:5.8 m, elevation: min.2.7, avg.4.8, max.5.6) are limited to dominance of Epilobium hirsutum and Polygonum hydropiper-group (IF:>60%, <5.7m TAW). The cause of absence of other species in the Durme needs more investigation. Future analyses on species level might better reveal the relative importance of tidal inundation duration and frequency on plant species presence along the salinity gradient.

Conclusions

Based on the main drivers, a habitat distribution model is made for the whole salinity and tidal regime gradients of the Scheldt estuary. With these models the potentials for tidal marsh development in new de-embankments for the whole Scheldt estuary can be predicted on a larger scale, including Natura- 2000 habitats of the Atlantic salt marshes and meadows (13) and Hydrophilous tall herb fringe communities of plains (6430).

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