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SALT MARSHES in the Water Framework Directive

Development of Potential Reference Conditions and of Potential Good Ecological Statuses

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Title	**Salt marshes in the Framework Directive Water;** *development of Potential Reference Conditions and Potential Good Ecological Statuses*
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Summary	The Water Framework Directive requires the description of Reference Conditions and Good Ecological Statuses of several ecological parameters and multimetrics for assessment. One of these parameters is 'salt marshes' (multimetric angiosperms). Due to many changes (embankments in particular) within the water bodies, no directly applicable Reference Conditions and GESes can be developed for them. Likewise, the development of multimetrics encounters problems, e.g. from the point of view of testing. To enable the development of a relevant multimetric we require the description of a Maximum Ecological Potential and a Good Ecological Potential. The directives for describing this MEP and GEP, however, have not been established for a long time. Therefore we have worked out an alternative, the Potential Reference Condition and the Potential Good Ecological Status. In this report we indicate the method according to which a Potential REF and a Potential GES may be described. In addition, we describe metrics for quantity and quality that may be used to test these P-REFs and P-GESes. Finally, we apply the metrics to the various waters to get an indication about how these metrics work out. This application is profitable for water managers, but equally for area managers, as it offers them an insight into the status of salt marshes in a water body as a whole and separately. In principle, the P-REFs and P-GESes developed here might be used in due time as MEPs and GEPs. *Rijkswaterstaat:* *RIKZ: National Institute for Coastal and Marine Management* *AGI: Geo-Information and ICT Department* In this version adjustments have been made: the acreages for Reed and Brackish marsh in Wadden Sea and Ems-Dollard have been changed for 1980 and 1990, as they had been mistaken..

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SALT MARSHES in the Water Framework Directive

Development of Potential Reference Conditions and of Potential Good Ecological Statuses

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SUMMARY

In this document we have developed two parameters for the Dutch salt marshes on behalf of the development of metrics with regard to the upholding of the European Water Framework Directive (WFD):

1. an acreage reference condition. The WFD departs from a pre-embankment acreage reference condition. This study on salt marshes started from historical references with embankments that were published already. It is new that the various preconditions per water body have been taken into account, making acreage-references turning out higher (entrapment dikes, Spartina) or lower(Afsluitdijk, Oosterschelde-barrier). Sometimes the present acreage has been applied as Reference Condition or as Good Ecological Status. In some cases, the current acreage is below the historical reference condition up to thousands of hectares: the entire Wadden Sea west, Oosterschelde, mainland Wadden Sea east.

2. a quality reference condition. We developed a quality reference condition for salt marshes on behalf of the WFD based on a comparison of vegetation zones (including climax stages) in the years vegetation was mapped around 1980, 1990 and 2000. The vegetation zones fit in with the present vegetation key (Salt97) and the international Wadden Sea-monitoring program (TMAP).

1. INTRODUCTION

1.1 The Water Framework Directive

The European Water Framework Directive (WFD) was enacted in December 2000. One of the obligations resulting from the WFD is the description of ecological reference conditions for natural water types. These reference conditions are the starting points for the ecological objectives for the water bodies. These references describe Reference Conditions and Good Ecological Status of several biological parameters; the latter is the boundary between the level at which a water body does or does not meet the standard of good biological water quality. To assess the actual situation metrics are being developed for these biological quality elements. In this report we do this for the quality element salt marshes, which is included in the quality element 'angiosperms' prescribed by the EU. We develop metrics and values for Reference Conditions and Good Ecological Statuses both for acreage and quality.

The WFD considers a 'natural water body' to be a water body that man has not or has hardly affected as far as hydro-morphologic interventions/effects are concerned. This is a very stern requirement and it involves, for instance, that there should be no embankments. As this is no serious option for the Netherlands, we developed in addition to this pure natural Reference Condition an adjusted (Potential) Reference Condition for the development of salt marshes, starting from the opportunities of each specific (sub-)water body. We describe the values for these Potential Reference Conditions and the Potential Good Ecological Statuses as well, for both acreage and quality, however, for each (sub-)water body separately.

1.2 WFD classification of Dutch water bodies

On behalf of the WFD the water bodies are divided into various categories of water types. Two of these are Transitional Waters (Dutch abbreviation O) and Coastal Waters (Dutch abbreviation K). Category K (Coastal Waters) is subdivided into several water types, K1 and K3, the open parts of the coast, with and without significant fresh water influences, respectively, and K2 the sheltered coastal waters. Within category O (Transitional Waters) we do not subdivide any further, we discern but O2 - estuaries with a tidal difference between 1 and 4 metres.
We have assumed the following for a classification of water types/water bodies [1]):

- O2 = transitional waters= Ems-Dollard + Westerschelde
- K2 = sheltered coastal waters= Wadden Sea + Oosterschelde
- K1 + K3 = coastal waters on the North Sea-side(island of Texel + the southwest of the Netherlands)

The Dutch salt marshes can be divided into 6 salt marsh types(**bold**) present in 8 (sub-)water bodies (see Figure 1 as well):

[1]) At the time we were writing this report no definitive classification of water types was official.

North Sea with the locations**:**
1a. The Slufter on the island of Texel (water type K3),
1b. The mouth of the Haringvliet (water type K1) and
1c. The mouth of the Westerschelde (water type K1)
Sandy salt marshes on islands with the sub-sectors**:**
2. Wadden Sea west of the Terschelling tidal divide (water type K2) [2)]
3. Wadden Sea east of the Terschelling tidal divide (water type K2) [3)].
- **Clayey salt marshes on the mainland** with the sub-sectors**:**
4. Wadden Sea Noord-Holland and Friesland up to the Terschelling tidal divide (water type K2),
5. Wadden Sea Friesland and Groningen (water type K2).
- **Saline salt marshes:**
6. Oosterschelde (water type K2) [4)].
- **Brackish salt marshes:**
7. Ems-Dollard (water type O2) [5)].
- **Brackish salt marshes:**
8. Westerschelde (water type O2) [6)].

[2]) Wadden Sea west of the Terschelling tidal divide (total tidal basin approx 155,000 ha):
- Big share of sublittoral (approx 50 %);
- Now there are hardly any salt marshes left;
- Geomorphologic preconditions have changed due to large-scale embankments on the island of Texel and in the north of Noord-Holland and by the damming off of the Zuiderzee.

[3]) Wadden Sea east of the Terschelling tidal divide (total tidal basin approx 95,000 ha):
Small share of sublittoral (approx 20 %), comparable to the German Wadden Sea;
At present relatively many salt marshes remaining.

[4]) Oosterschelde = total tidal basin approx 35,000 ha

[5]) Ems-Dollard = total tidal basin approx 10,000 ha

[6]) Westerschelde = total tidal basin approx 31,000 ha

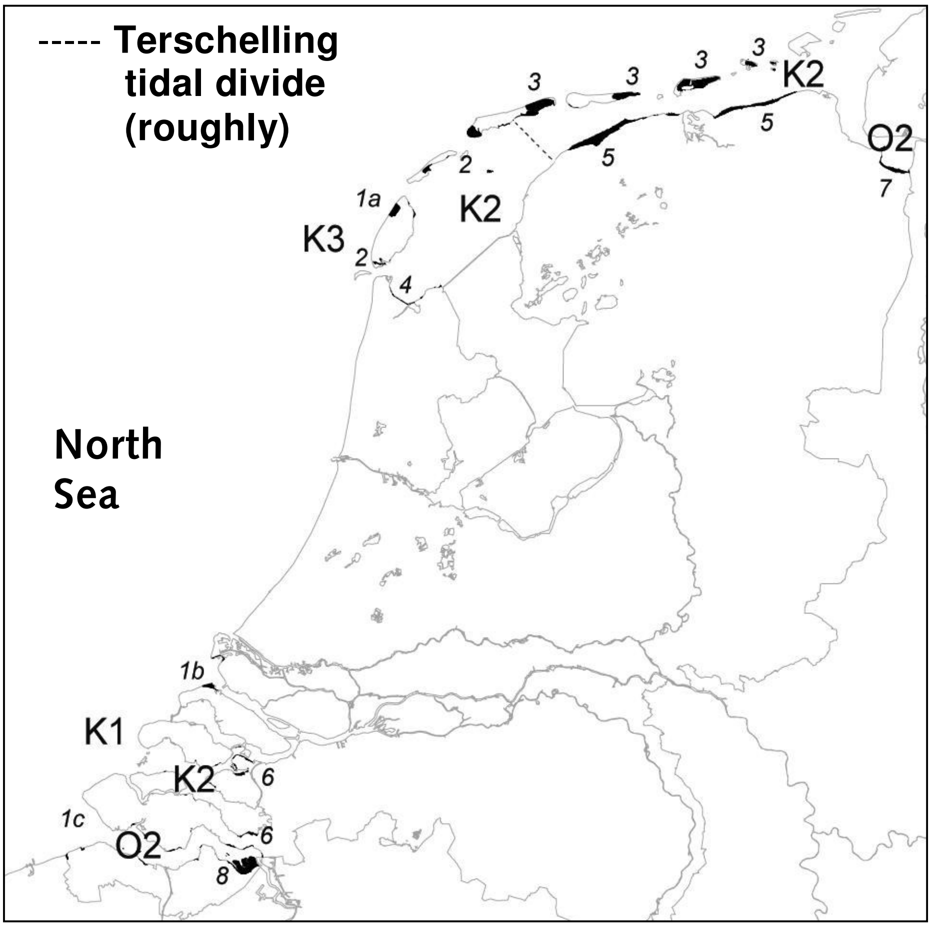


Figure 1.1. The Dutch salt marsh areas (dark grey), the water types (**C**apitals) and the salt marsh types (numbers ***in italics***).

1.3 Development of reference conditions for salt marshes

We assume the situation before the embankments with minor human influences to be the **acreage reference condition** for salt marshes in the sense of the WFD. This is roughly the situation as it was in Roman times and in the early Middle Ages. This situation cannot be quantified and cannot be restored either. Therefore, we are working in this study mainly with a **potential reference condition (P-REF)** and **potential Good Ecological Status(P-GES).** We elaborate upon them in Chapter 2.
For the Wadden Sea and the Ems-Dollard it is the situation in which an equilibrium existed between impolderings and new accretions. That situation takes the various preconditions into account per (sub-)water body, including land reclamation works and the like and has been quantified in existing publications. For the southwest of the Netherlands primarily the opportunities within the present embankments are taken into account, considering the effects of the introduced rice grass (*Spartina anglica*). If these positive human influences on the originating of salt marshes are not taken into account, then opportunities for salt marshes in the current situation are very limited in the Netherlands.

We developed a **quality reference condition** based on three sets of vegetation maps by RWS-AGI (around the years of monitoring 1980 , 1990 and 2000). The quality reference condition is based on a well-balanced distribution of vegetation zones. In the Wadden Sea the zones have been attuned to the zone division in the international TMAP-monitoring. The salt marsh type in the southwest of the Netherlands is clearly different in character and has its own zone division (see Appendix 1). We elaborate upon the quality reference condition for the salt marshes in Chapter 3.

2. REFERENCE CONDITION ACREAGE FOR SALT MARSHES

2.1 Introduction into the reference condition for acreage

"Good" salt marshes make high demands on their minimum size, the acreage. A minimum acreage is necessary because of the vulnerability of small sites, the preservation of biodiversity and in order to enable regeneration by cyclic development. Beeftink (1984) and the 'Handboek Natuurdoeltypen' ('Guide of Nature Target Types', Bal et al. 2001) mention a **minimum acreage of 500 ha** per sub-water body to this end. Only then the thus defined potential biodiversity is possible:

- variation based on the geomorphologic preconditions and
- diversity in vegetation zones and plant communities with the accompanying biotopes for invertebrates and birds.

In the Wadden Sea and in the southwest of the Netherlands considerable areas of salt marshes occur as seen on an international scale. These salt marshes, however, are a modest remainder of the vast saline and brackish landscapes, peat regions and lakes that were situated in the borderlands between the Pleistocene land surface and the sea until about some 1000 years ago. The WFD takes this un-embanked situation with minor human influences as the **reference condition**. Although from that time on our ancestors started to dam and embank inhabited areas, considerable floodings by the sea and accretion of salt marshes were continuously taking their turns. It was not before approx 1600 that damming and embankments played such a dominant role that in the interaction between embankment and accretion gradually less and less salt marshes remained. The embankments of the mainland are nowadays impregnable fortresses not allowing the edges of the wadden system to retreat. Hydrodynamics have decreased further by entrapment dikes at the east sides of most Wadden islands, causing salt marsh accretion. A historical Reference Condition, based on the period before the embankments, is utopia (Dijkema 1987; Esselink 2000). Based on the geologic information it is known that in this period vast acreages of salt marshes existed. However, as the water bodies' situation and size were completely different at the time, these numbers are hardly to translate, for instance, into a standard of acreage as a percentage of salt marsh per water type. From this historical point of view, we developed in this report a **Potential Reference Condition (P-REF)** that takes per (sub-)water body the strongly varying preconditions into account.

2.2 Preconditions for accretion

Salt marshes originate by nature on intertidal flats with adequate height, with sheltering against waves and currents and with adequate supply of sediment and plant parts or seeds. In an interaction between physical and biological processes, tidal flats with a few pioneer plants develop into a salt marsh vegetated with halophytes that is situated above mean high water and with an accompanying geomorphologic pattern of creeks, levees and basins. A pure natural accretion of the Dutch salt marshes has become a rare phenomenon these days.

The natural reaction of the Wadden Sea on sea level rise is a landward retreat of the sandy coast (barrier islands), tidal flats and mainland salt marshes. This reaction frees enough sand to maintain the total wadden system permanently[7]). Large parts of the so-called basic coastline have been kept steady by sand suppletions on beaches or underwater shores in front of the islands since 1990. This supplied sand moves via the outer deltas and the tidal inlets with the current to the Wadden Sea and causes indirectly the height of the tidal flats keeping pace with the current sea level rise.

The natural mechanism of the retreating wadden system due to sea level rise could lead in combination with a **fixed mainland coast** to the notion that the shortage of salt marshes can be ascribed to this. By this so-called "coastal squeezing" a rigid transition forms. Flemming & Nyandwi (1994) conclude based on two transects in Ostfriesland (Germany) that the Wadden Sea has become too small (too narrow) for a normal gradient in energy with the accompanying increase of the fine (silt-) fractions in the sediment towards the mainland coast. There are opportunities, however, for the formation of salt marshes in the Wadden Sea at sites where it is most narrow (eastern Wadden Sea), beit that man should help with reclamation works and dams. This is probably a question of shelter against wave attacks by the islands.

A second obvious explanation for the lack of natural accretion along the mainland is that embankments have straightened out the coastline. A rugged coastline with many inlets offers more **shelter against waves and currents** and enables natural accretion. Areas with low wave energy and current energy are still being found in the shelter of the reclamation works (and of some Dutch and German ferry-dams and German dams to the islands). Salt marsh accretion in the remaining natural bights in the Dollard and the Jadebusen, however, has decreased. Possibly large-scale dredging works in the shipping lanes and their resulting rise of MHW play a role in this.

In the southwest of the Netherlands the importance of shelter is expressed in the location of the salt marshes in the parts that are mainly landward. Moreover, the planting (and degeneration) of rice grass has played a large role in the size of the current acreages.

2.3 Quantification of historical acreage

2.3.1. Method of quantification of historical acreage

Dijkema (1987, Figure 2.1) reconstructed the historical acreages of salt marshes in the Wadden Sea since 1600 and plotted them on the current topographical map. This is possible as the embankment history is very well known. Furthermore, as many recognizable details as possible on the location of salt marshes in historical maps have been transferred to the same topographical map. Subsequently, he measured the acreages of salt marshes and depicted them graphically. He opted to work with

[7]) The mechanism that is involved is called "sand sharing system": the islands' foreshores, the beaches, the outer deltas, the tidal inlets, the inner deltas, the tidal flats and the tidal channels and gullies are all part of one big sand pit. A possible shortage of sand will be spread across the whole of this sand pit by natural forces. From this point of view sand suppletions from the deeper North Sea in the sand sharing system, but from outside the actual Wadden Sea, are a management measure from which the whole wadden-system could benefit.

reference years instead of acreages added up in, for instance, one hundred years. The reference years 1600, 1700, 1800 and 1860, have been selected in such a way that they precede series of embankments. In addition, the first topographical maps are available around 1860. The year 1925 is representative for a period of problems in salt marsh accretion, followed by the large-scale reclamation works by the government (now managed by Rijkswaterstaat). The mentioned historical analysis is the basis for the approach of the acreages in the Dutch policy for the Wadden Sea. We have taken the salt marsh zone + the pioneer zone vegetated > 5 % for the Wadden Sea. This is comparable to the international TMAP-monitoring and the reason that the share of pioneers along the Groningen and Friesland mainland is relatively high and varies extremely from year tot year.

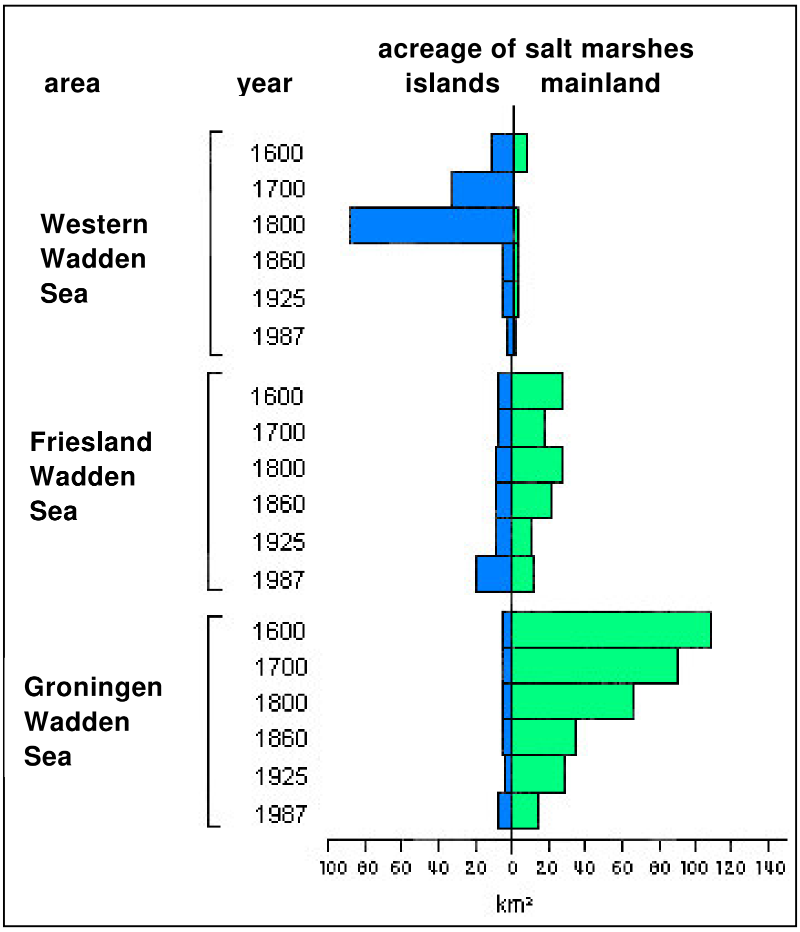


Figure 2.1
Acreage of salt marshes in the Dutch Wadden Sea after 1600 AD in km^2 (1 km^2 = 100 ha). The Wadden Sea west of the Terschelling tidal divide includes the island of Huisduinen (K2) and the Slufter (K3) on the isle of Texel, but excludes the Zuiderzee. The Groningen Wadden Sea includes the isle of Schiermonnikoog (K2) and the Dollard (O2).
The salt marshes in 1987 are without summer polders and without the pioneer zone along the mainland.
The salt marshes of 1600-1800 of the islands of Ameland, Schiermonnikoog and Rottumeroog have been equalled to 1860.
After Dijkema (1987).

For the southwest of the Netherlands a digital overview of the acreage of salt marshes was made recently, based on maps from 1856, 1910, 1938, 1960, 1978, 1988 and 1995 (Van der Pluijm & De Jong 1998; Table 2.1). Very large creeks such as those in Saeftinghe (750 ha of creeks) have not been included as salt marsh in their overview. In this study for the southwest of the Netherlands the salt marsh zones + the pioneer zone vegetated > 0.1 % has been included, as the pioneer zone is relatively steady here.

2.3.2. *Changes in historical acreage per (sub-)water body*

In the following sections we describe the historical acreage changes per (sub-) water body.

a) Wadden Sea west of the Terschelling tidal divide

Mainland salt marshes were hardly important (except for the Zuiderzee) in the Wadden Sea west of the Terschelling tidal divide after 1600 AD. Huisduinen and Wieringen in the north of the province of Noord-Holland were still islands at the time. The salt marshes on the islands accreted in the 18th century to the considerable acreage of 8,850 ha. This was enabled in the shelter of the entrapment dikes between the islands of Huisduinen and Callantsoog in the north of the province of Noord-Holland (Koegras 1610) and between the islands of Texel and Eierland (1629). The complete embankment of the Koegras in 1817 (as side-effect of the digging of the Noordhollands kanaal !) and of Eierland in 1835 caused a minimization of the salt marshes in the western Wadden Sea (Figure 2.1).

Two conditions have hampered (new) accretion of salt marshes in the western Wadden Sea up to now. First, both salt marshes and vast areas of bordering tidal flats and sublittoral water expanses have been embanked here in previous centuries (6,600 ha in the 19th century: the Anna Paulownapolder and the polder Waard-Nieuwland in the north of the province of Noord-Holland and the Prins Hendrikpolder and polder Het Noorden on the island of Texel). A method contrasting sharply with the rest of the Dutch -German- Danish Wadden Sea where until a few decades ago only "mature" salt marshes were embanked (the Johannes Kerkhovenpolder from 1878 in the Dollard is the only historical exception). **This caused that along the edges of the north of the province of Noord-Holland and of the isle of Texel few high tidal flats were left on which new accretion would be able to take place.**

Secondly, the western Wadden Sea has different geomorphologic preconditions than the eastern Wadden Sea due to its small tidal amplitude (micro-tidal = 0-2 m; Hayes 1975, 1979), the great effect of wind waves, the small share of emerging tidal flats (littoral) and the construction of the Afsluitdijk (causes: increase of the MHW and a long-lasting lack of sand in the sand sharing system) . **A micro-tidal system, seen globally, has a small salt marsh acreage, in particular along the mainland coast**. This can easily be seen by the vast sublittoral expanse of water that is present in front of the Afsluitdijk and which continues beyond Harlingen. This permanent water expanse means that the area between the inner deltas and the mainland is not (yet) filled up with sediment, which is typical of micro-tidal systems.

b) Wadden Sea east of the Terschelling tidal divide

The preconditions for salt marsh accretion along the mainland coast in the eastern Wadden Sea are much more favourable by nature than in the western Wadden Sea. This difference is shown in Figure 2.1 by the larger acreage of salt marshes in Friesland and Groningen, which is larger still when the relatively small size of the eastern Wadden Sea is taken into account. Groningen had a considerably larger share of it until 1800 than Friesland (in 1600 7,900 ha of salt marshes in Groningen compared to 2,700 ha in Friesland). After a series of large embankments at the beginning of the 19th century along the north coast of the province of Groningen (including the Noordpolder of 3,500 ha in

1811) the acreage in both provinces is now small (1,000 ha in Groningen and 1,200 ha in Friesland). **The present mainland salt marshes are the result of human influences**: reclamation works on behalf of land reclamation. Whenever accretion halted, it was caused by (too) little effort in the reclamation works (e.g. the situation around 1925 when the reclamation works were still a private initiative and recently in the Dollard). Based on historical maps, the acreage of island salt marshes in the eastern Wadden Sea has been stable until the embankments took place (island of Schiermonnikoog 1860, island of Ameland 1915-1930). The old island salt marshes have vanished obviously due to these embankments, but soon strong accretions were taking place in the shelter of new entrapment dikes (e.g. the Boschplaat 1,300 ha after 1931). The present acreage of island salt marshes. In Friesland (2,650 ha) has become even much larger than that of the mainland salt marshes.

c) Ems-Dollard

On either side of the mouth of the river Ems there are island salt marshes (see eastern Wadden Sea). No salt marshes are present on the Dutch and neither on the German side of the river Ems up to the mouth of the Dollard. The salt marshes of the Dollard start at the Punt van Reide, an old spit without embankments with the character of a Hallig. Due to silting up and strong shore protections the Punt van Reide has survived all storm-surge disasters as a salt marsh. The Dollard originated by floodings of the sea after 1277 and had its largest size of approx 40,000 ha in 1520 (Esselink 2000). The submerged lands have accreted at a high pace from the edges with salt marshes that were embanked in an unprecedented pace of two 'embankment skins' per century. During the embankment period, about 1,000 ha of salt marshes continued to be present (Figure 2.1). The current salt marsh of 741 ha originated from reclamation works in the mid-previous century. The accretion has stopped and the current salt marshes are slightly eroding at the seaward side

d) Oosterschelde

In the Oosterschelde salt marsh accretion mainly stopped at the end of the 19th century because of the lack of space. Therefore, only on a limited scale traditional embankments on behalf of agriculture have taken place in the Oosterschelde after 1870. Due to the decreased supply of fine sediments after the construction of the dams in the Kreekrak and the Sloe (Storm 1999) the introduction of the exotic species rice grass (Spartina x townsendii) affected rather little accretion in the Oosterschelde itself, but on the contrary much in the neighbouring Krammer-Volkerak (see the accretion in the reference years 1938 and 1960 in “Oosterschelde behind the dams” in Table 2.1). Due to the construction of the storm surge barrier in 1986 the marine character of large parts of the Oosterschelde has been preserved at the last moment. Since that year, however, the total acreage of salt marshes in the Oosterschelde has been reduced to two thirds of its former size. The 523 ha still remaining in 2001 continue to erode further. Causes are: (1) the construction of dams causing the largest salt marsh areas in the Krammer-Volkerak and part of the eastern Basin to be dammed off, (2) reduction of the tidal amplitude with approx 10 %, resulting in a lack of sediment and making the wave attack now aimed at the edges of the salt marsh and (3) the general silting up of the salt marshes making them vulnerable to erosion (think of the natural cycle of accretion-erosion-accretion-etc).

e) Westerschelde

In the Westerschelde as well the salt marsh accretion stopped at the end of the 19th century. The introduction and planting of rice grass in 1925 has played a major role in the changes in the salt marsh acreages. Due to the establishment of Spartina a spectacular accretion of salt marshes has occurred in the four sub-areas Sloe, Braakman, Ossendrecht and Saeftinghe. The acreages before and after 1925 in Table 2.1 are therefore based on different preconditions. The acreage of salt marshes in the western and central parts of the Westerschelde has decreased strongly afterwards due to embankments. Most areas of 'mature' salt marshes were brought under cultivation as soon as possible for agriculture, including the inlets of the Zuid-Sloe (300 ha) and the Braakman (650 ha). The remaining part of the Zuid-Sloe was embanked in 1962 for industrial purposes. In the eastern part the salt marshes near Ossendrecht (600 ha) disappeared around 1970 due to embankments on behalf of the digging of a canal. In one sub-area, the Verdronken Land van Saeftinghe, the enormous accretion has been preserved. The decrease of the total salt marsh acreage in the Westerschelde after the introduction of Spartina has been limited to one third thanks to this large accretion in Saeftinghe.

	Period without Spartina		**Period of introduction of Spartina**		**Period with Spartina**		
	1856	**1910**	**1938**	**1960**	**1978**	**1988**	**1995**
Transitional Water (O2):							
Haringvliet (dam 1970)	1,262	1,805	2,375	2,415	-	-	-
Westerschelde	2,802	2,245	3,657	3,631	2,340	2,366	2,513
Coastal Water (K2):							
Grevelingen (dam 1971)	327	203	226	344	-	-	-
Veerse Meer (dam 1961)	649	627	799	858	-	-	-
Oosterschelde behind the dams (dams1987)	1,093	1,293	1,445	1,526	1,017	-	-
Oosterschelde in front of the dams	1,147	706	563	650	629	544	523

Table 2.1 Acreage of salt marshes in the southwest of the Netherlands in ha.
After Van der Pluijm & De Jong (1998).

2.3.3. Changes in historical acreage of salt marshes

The acreage of salt marshes gradually has changed by a combination of mainly human factors. The factors that can be discerned are:

A. Improved protection of the coast and large hydraulic engineering works

- Natural salt marshes along the mainland of the Wadden Sea and natural salt marshes in the tidal inlets of the southwest of the Netherlands occurred mainly in sheltered **bights of the coastline**. Those bights have mainly disappeared due to embankments.
- In the western Wadden Sea the conditions for salt marsh formation have strongly changed due to the construction of the **Afsluitdijk** and a historical Reference Condition is not possible that well. On the island of Texel and along the mainland

of the province of Noord-Holland hardly any salt marshes are present due to large-scale embankments. Along the Afsluitdijk and NW Friesland no salt marshes are present.

- the sharp decline of salt marshes in the Oosterschelde is caused by a difference in the preconditions by the construction of the **Oosterschelde storm surge barrier** in 1986. The largest salt marsh areas in the Basin (= eastern part) and in the Krammer-Volkerak have disappeared behind dams and the decrease of the tidal amplitude enhances the lack of sediments and the wave energy.

B. Traditional embankments

- Usually, the pace of embankment was greater than the accretion of new salt marshes. Due to "**coastal squeezing**" people had to make do with increasingly smaller polders.
- Big embankments and "coastal squeezing" made that the Wadden Sea probably has become too narrow to have adequate quiet conditions along the mainland coast to enable natural salt marsh development.
- Due to the smaller polders and better techniques new dikes were constructed increasingly nearer or even beyond the edges of the salt marshes. At places where the dikes are sitting on the tidal flats (e.g. Sloe, Noord-Holland, Lauwerszee, Eemshaven, Ems) salt marshes will be absent for a relatively long time because of the lack of high tidal flats and/or because they are rather exposed.

C. Stimulation of salt marsh accretion

- In the Westerschelde a spectacular accretion took place in the last century due to the introduction and planting of **rice grass** from 1925. Only in Saeftinghe this accretion has not been embanked. The total decrease of acreage of salt marshes in the western and central parts of the Westerschelde was huge due to embankments and exceeded the accretion at Saeftinghe.
- The salt marsh accretion along the exposed north coast in the Wadden Sea has mainly taken place due to human influence: the **reclamation works**. In comparison with the historical reference condition, the acreage of the mainland salt marshes still is exceptionally low. The coast along Het Bildt, province of Friesland, is unique as after the construction of the Afsluitdijk a surge of silt has supplied an extremely high accretion for years on end. At the moment the sublittoral between the inner-delta and the mainland is being filled there.
- On the eastern wadden islands more salt marsh acreages have originated due to the construction of **entrapment dikes** than could be expected based on the historical Reference Conditions. In the long run a negative effect of entrapment dikes on the acreage of salt marshes should be expected due to the obstruction of direct sand transport from the North Sea via "wash overs".

2.4 Potential Reference Conditions and Potential Good Ecological Status for acreage

2.4.1. Method of assessment of Potential Reference Condition of acreage (P-REF)

The Potential Reference Condition of acreage replaces the Reference Condition of acreage, as an actual, undisturbed reference status of the Dutch salt marshes of before the embankments cannot be reconstructed. In the assessment of the Potential Reference Condition we started from the present embankment situation and from human activities aimed at salt marsh development that have been carried out in the recent past and are still being carried out; e.g. reclamation works; entrapment dikes and planting of rice grass. If these human activities are left out then the opportunities for salt marsh development in all water bodies are but very little. One can think of a maximum of some tens of per cents of the current size. We think this assumption not to be very realistic and therefore we are taking the current efforts for granted.
The Good Ecological Status (GES) is the situation that is minimally required in a water body on the scale in five parts that ranges from the ideal "Reference acreage" to the "bad ecological status". The Potential Good Ecological Status for acreage (P-GES) is assessed based on P-REF. Mostly it consists of a certain part of P-REF, however if the acreage turned out to be smaller than the minimum acreage (500 ha) then we applied the latter.

The current share of salt marshes as percentage of the total intertidal area appears to vary from 7.5% - 14% in water systems with favourable conditions of silting up or where relatively few embankments are present (Danish Wadden Sea, Dollard, Westerschelde, Wash) to 1.5% - 4% in water systems with many embankments or with bad conditions of silting up (Wadden Sea of Schleswig-Holstein, Niedersachsen and the Netherlands; Oosterschelde).
Dijkema (1987) quantified what the extent of the salt marsh acreage in the eastern Wadden Sea would be if the processes of accretion and erosion were balanced. We quantified the share of salt marshes in **percentages of the tidal basin as a whole** in which they are situated in order to be able to compare the acreage of salt marshes for various years and areas. A reference value for the acreage of salt marshes has been found by looking for a period in which a global balance between the processes of accretion and erosion is present. We took it for salt marshes in the Wadden Sea to be a global balance between embankments and (natural or artificial) accretion, a situation that occurred **between1600 and 1800 AD** (Figure 2.1). We have taken the average percentage of salt marshes of the total intertidal area from that period as the value for **Potential Reference Condition** of acreage. We calculated with this percentage how much salt marsh acreage should be present at the moment, in a smaller Wadden Sea, in a balanced situation between embankments and accretion. Such a P-REF, therefore, depends on the size of the total Wadden Sea.

The introduction and planting of rice grass (Spartina x townsendii) from 1925 onward played an important role in the changes of salt marsh acreage in the southwest of the Netherlands. The acreages before and after 1925 in Table 2.1, therefore, are based on different preconditions. As Potential Reference Condition **(P-REF)** for the current situation in the SW Netherlands (since this is with Spartina as well) we have chosen the **reference years 1938 and 1960** (Table 2.1).

Slufters and green beaches are part of a dynamic dune coast and come and go analogously with the changes in that dune coast. In a stable, fixed dune coast the chances of a long-lasting presence are limited unless man intervenes periodically to keep open for instance supply channels. Only in the case of adequate size of the area to be flooded there are opportunities for long-lasting preservation. From the past little is known about numbers and size of this kind of areas. We therefore make choices based on the current situation and the opportunities expected.

2.4.2. Results of the Potential Reference Conditions of acreage (P-REF)

a) North Sea

This involves the slufters and green beaches on the North Sea side of the wadden islands, the Holland coast and in the mouths of the Haringvliet and the Westerschelde. A historical reference in not (yet) known. We suppose that in the past in the case of a coastline with many breaches there have been many sites. The number of sites in the current situation is very limited. Sites on the wadden islands are The Slufter on the island of Texel (257 ha), but possibly sites on the islands of Terschelling, Ameland and Schiermonnikoog may be classified in this category as well, in particular the green beaches. The only site on the Holland coast is the (artificial) Notch near Schoorl (very limited). Sites in the southwest part of the Netherlands are: Kwade Hoek (and to a lesser degree 'Westplaat' near Oostvoorne) in the mouth of the Haringvliet (a total of 230 ha) and the Verdronken Zwarte Polder and 't Zwin in the mouth of the Westerschelde (a total of approx 57 ha[8])). P-REF and P-GES[9]) will have to be estimated.

North Sea
1a. The Slufter on the island of Texel (Water type K3),
1b. Mouth of the Haringvliet (Water type K1) and
1c. Mouth of the Westerschelde (Water type K1)
P-REF-acreage 1 = not assessable
We opted for a minimum number of locations: 2 per water type. = a total of 4.
Slufter areas are very dynamic from a historical point of view and we know little of their numbers and situations in the past. An acreage reference condition based on the past cannot be assessed. Slufter areas are isolated by definition and it is not advisable therefore to apply the ecological minimum acreage of 500 ha for various (sub-)water bodies together. A "good ecological status" of K1 and K3 is reached if (1) a slufter region is adequately large to keep open the linking channel to the North Sea without human interference and (2) more than one slufter are present.

P-GES-acreage 1 = not assessable
We opted for a minimum number of sites: 1 per water type. = a total of 2.
A further reference for acreage is not advisable.

NB If the North Sea coast will be designated as one water type, then P-REF becomes 4 locations per water type. and P-GES 2 locations per water type., with respect to the much greater length of the coastal area in that case.

[8]). Only the Dutch part has been included.

[9]) P-REF = Potential Reference Condition; P-GES = Potential Good Ecological Status.

b) Wadden Sea west of the Terschelling tidal divide

A historically assessed reference for the western Wadden Sea **is not possible for salt marsh acreages as the geomorphologic preconditions have changed drastically**. The acreage was 1,250-8,850 ha in the period 1600-1800 AD. After the large embankments the acreage had decreased to approx 700 ha in the period 1860-1925 AD. Now only 301 ha of island salt marshes are left (after the construction of the Afsluitdijk) (including the pioneer zone > 5 %) and 71 ha of mainland salt marshes (Balgzand-Breehorn, including the pioneer zone > 5 %). The current preconditions are undeniably bad for accretion of salt marshes (see the small shares of salt marshes in % of the tidal basins in Table 2.2). For the time being no essential recovery is expected as (1) in the north of the province of Noord-Holland and on the island of Texel virtually all areas enabling salt marshes to develop in the short run are embanked and as (2) the edges of the tidal basin along the Afsluitdijk and beyond Harlingen are situated too deep still, even below the low water mark (sub-littoral). A local exception is the recent natural accretion in the Slikhoek (mud-corner) at the Van Ewijck-locks (Balgzand)

Western Wadden Sea (sub-)water bodies 2 en 4	Historical references			Present acreage of salt marshes	
	% salt marshes 1600-1800	% salt marshes 1860-1925			
Water type K2	%	%		ha	%
Western Wadden Sea = approx 155,000 ha at present	0.8 – 5.7	0.5	Islands	301	0.2
			Mainland	71	0.05

Table 2.2 Salt marshes in the western Wadden Sea (west of the Terschelling tidal divide). Current acreage based on the most recent vegetation maps by RWS-AGI. Island salt marshes including the pioneer zone > 5 % and excluding the Slufter on the island of Texel. Mainland salt marshes Balgzand-Breehorn including the pioneer zone > 5 %.

Western Wadden Sea
2. Wadden islands west of the Terschelling tidal divide (K2)
P-REF-acreage 2 = not assessable.
If we compare the present acreage (301 ha, including the pioneer zone > 5 %) with the historically assessed acreages then 630 to 8,230 ha of salt marsh acreages are lacking. The wide range in the historical acreage is caused by the construction of entrapment dikes in the north of the province of Noord-Holland and on the island of Texel and the subsequent embankments of the salt marshes thus formed. In the western Wadden Sea there are hardly any salt marshes left (an unprecedented low share of 0,2 % of the intertidal areas) and restoration is not realistic as the geomorphologic preconditions have changed essentially due to the large scale embankments and the construction of the Afsluitdijk.

4. Noord-Holland and Friesland mainland up to the Terschelling tidal divide (K2)
P-REF-acreage 4 = not assessable.
A historically assessed acreage Reference Condition for these mainland salt marshes is impossible to determine. The preconditions have changed drastically due to the damming off of the Zuiderzee. The only mainland salt marshes are now to be found in the Balgzand-Breehorn area (71 ha, including the pioneer zone > 5 %). At Westhoek in the province of Friesland at the border of Het Bildt we find a modest pioneer zone at the high tidal flat that has not been mapped and is not yet included.

Western Wadden Sea total
In view of the exceptionally bad preconditions we opted for an **ecological minimum acreage** for the islands (2) and the mainland (4) together:
P-REF-acreage 2 + 4 = minimum acreage opted for 1000ha (including pioneer zone > 5 %); for each salt marsh type the minimum acreage.
P-GES-acreage 2 + 4 = minimum acreage opted for 500 ha (including pioneer zone > 5 %); for both salt marsh types together the minimum acreage.

c) Wadden Sea east of the Terschelling tidal divide

Based on the method of 2.4.1 the historical reference for the Friesland Wadden Sea has an average of approx 6 % and for the Groningen Wadden Sea it has an average of approx 10 % of the tidal basins (see Table 2.3). The island salt marshes are well over 1,900 ha above a historical Reference Condition due to the accretion of salt marshes behind entrapment dikes. The mainland salt marshes are well below 4,220 ha below P-REF, despite the results of the reclamation works. This is caused by the fact that accretion was not able to keep pace with losses caused by embankments in the past centuries.

Eastern Wadden Sea (sub-)water bodies 3 and 5		**Historical reference (= % 1600-1800)**		**Present acreage of salt marshes**		**Difference with reference c.f. 2.4.1**	
Water type K2		%	ha	ha	%	%	ha
Friesland (from Terschelling tidal divide to Zoutkamperlaag = approx 45,.000 ha at present)	Islands (3)	1.4	630	1,685	3.7	+ 2.3	+1,055
	Mainland (5A)	4.2	1900	1,310	2.9	-1.3	- 590
	Summer polders without seaward dike			250			
Groningen (Schiermonnikoog including = approx 50,000 ha at present)	Islands (3)	0.6	300	1,167	2.3	+ 1.7	+ 867
	Mainland (5B)	9.3	4,650	1,000	2.0	-7.3	-3,650

Table 2.3 Salt marsh acreage in the eastern Wadden Sea compared to the reference condition (after Dijkema 1987). Present acreages on the mainland based on plots[10]) 2002, including 700 ha farmland salt marshes, 100 ha salt marshes in NE Friesland and exclusive 400 ha pioneer zones vegetated >5%. Current acreage on the islands is based on the most recent vegetation maps of RWS-AGI, including the pioneer zone > 5 %.

3. Wadden islands east of the Terschelling tidal divide (K2)
P-REF-acreage 3 = 2,800 ha (excluding the pioneer zone <5%)**.**
The historical Reference Condition of 930 ha in Table 2.3 is based on the situation without entrapment dikes. If we compare that number with the present acreage of 2,852 ha, then the salt marsh acreage is 1,922 ha larger than the historical reference condition. We have taken into account in the assessment of P-REF that the present vast acreages offer some compensation for the extremely bad situation in the western Wadden Sea.

P-GES-acreage 3 = 2,000 ha (excluding the pioneer zone < 5 %).
P-GES is based on fewer entrapment dikes that are preserving approx **2/3 parts** of the present salt marshes on the islands.

KPD-policy discerns between reclamation works and 'summer polders' of which the seaward dikes are to be removed; these acreages are not 'interchangeable'. A possible removal of the seaward dikes of the summer polders is a nature target in itself and it cannot lead to the rejection of reclamation works based on the formulated KPD-policy. $^{1}/_{3}$ part of the salt marshes should be situated in one of each province based on the internal function-requirement by RWS (see 2.5; method a).

[10]) Plots as a basis for acreage assessment of reclamation works on the mainland side, because 1) the acreage assessment is more accurate in them in particular for the pioneer zone >5% and 2) these acreages are used in the testing of the preservation plan.

5. Mainland salt marshes Friesland and Groningen (K2)
P-REF-acreage 5A Friesland = 1,900 ha (excluding the pioneer zone < 5 %).
If we compare the present acreage to the historical Reference Condition, then there are 590 ha of salt marsh acreage lacking. The acreage of salt marshes within the reclamation works in 1980 was 569 ha, that acreage has increased in 2002 to 810 ha (figures based on plots, without 400 ha farmland salt marshes and without the pioneer zone < 5 % cover = remained the same of 360 ha).
P-REF-acreage 5B Groningen = 4,650 ha (excluding the pioneer zone <5%). If we compare the present acreage with the historical Reference Condition, then 3,650 ha of salt marsh acreage are lacking. The salt marsh acreage within the reclamation works in 1980 was 767 ha, that acreage has decreased in 2002 to 701 ha (figures based on plots, without approx 300 ha of farmland salt marsh and without the pioneer zone < 5 % cover = decreased from 490 to 90 ha).
Total P-REF-acreage 5A + 5B = 6,550 ha (excluding the pioneer zone <5%). For the province of Groningen a complete restoration to this Reference Condition is not realistic. The historic acreage Reference Condition of the province of Friesland may be achieved with the removal of seaward dikes of the summer polders (see 2.5).

P-GES-acreage 5A + 5B = 2,600 ha salt marshes (globally 700 ha of farmland salt marshes + 100 ha salt marshes in NE Friesland + 1,400 ha salt marshes and 400 ha of pioneer zone > 5 % in the reclamation works). The current salt marshes are continuous per province and are per area considerably more than the ecological minimum acreage. It deserves the predicate of "Good Ecological Status". Therefore, we assess P-GES 5A + 5B at the present acreage – 5 %, 1/3 of which (approx 900 ha) in the province of Groningen. 5% is required to build in some margins with respect to the dynamics that are to be present in the salt marsh's seaward edge.

d) Brackish salt marshes Ems-Dollard

Based on the method in 2.4.1, the historical Reference Condition of the Dollard salt marshes is approx 10 % of the tidal basin (see Table 2.4). The present salt marshes are 280 ha less than the reference condition. The salt marshes in the Dollard are the result of reclamation works (in the past) and many have been embanked. However, in the Dollard accretion virtually kept pace with losses due to embankments in the past. Accretion stopped however in the mid-twentieth century after reclamation works ended and therefore some slight erosion is occurring at the seaward side of the salt marshes presently.

Ems-Dollard (sub-)water body 7		Historical reference (= % salt marshes 1600-1800)	Present acreage of salt marshes		Difference with reference see 2.4.1	
Water type O2		%	ha	%	%	ha
Dutch Ems-Dollard = approx 10,000 ha at present	Dollard + Punt van Reide	10.2	741	7.4	-2.8	-280

Table 2.4 Acreage of salt marshes in the Ems-Dollard compared to the Reference Condition (after Dijkema 1987). Present acreage of salt marshes in the Dollard based on the most recent vegetation map by RWS-AGI, including the pioneer zone > 5 %.

7. Salt marshes of the Ems-Dollard (O2)
P-REF-acreage 7 = 1,000 ha (including the pioneer zone > 5 %).
The spatial distribution of the salt marshes in the Ems-Dollard lies unilaterally in the Dollard. Along the river Ems between the mouth of the Dollard and the Wadden Sea no salt marshes were present on the German and either on the Dutch side in the reference period 1600-1800, before that period they were present in the embanked tidal inlet of the Fivel. In the Wadden Sea bordering the Ems-Dollard mainland salt marshes are present both on the German and Dutch sides (Groningen, Leybucht) and island salt marshes (Rottum islands and Borkum) as well. The current salt marsh acreage in the Dollard is 741 ha, including the (secondary) pioneer vegetation > 5 %. If we compare the present acreage with the historically assessed Reference Condition, then 280 ha of salt marshes are lacking.

P-GES-acreage 7 = 700 ha (including the pioneer zone > 5 %).
Despite the shortage with respect to the historical Reference Condition the share of salt marshes is relatively large (7.5 % of the intertidal area, similar to the Westerschelde) and the acreage is well over the ecological minimum acreage. It deserves the predicate of "Good Ecological Status". Therefore we assess P-GES at the **present acreage - 5%**; 5% is required to build in some margins with respect to the dynamics that have to be present at the salt marsh's seaward edge.

e) Saline salt marshes Oosterschelde

A historical Reference Condition for the Oosterschelde is not assessable as the geomorphologic preconditions have changed drastically. The historical Reference Condition before the construction of the storm-surge barrier, before the division into compartments and after the introduction of Spartina was approx 1,500 ha (3.5 % of the tidal basin; Table 2.5). The percentage of salt marshes for the Oosterschelde in its present shape and size is 1.5 % (523 ha).

Oosterschelde (sub-)water body 6	Historical reference (= % salt marshes 1938-1960)	Present acreage of salt marshes	
Water type K2	%	ha	%
Oosterschelde = approx 35,000 ha at present (Nienhuis & Smaal 1994)	3.5 %	523	1.5 %

Table 2.5 Salt marshes Oosterschelde. Salt marsh acreage Oosterschelde based on Van der Pluiim & De Jong (1998) and the vegetation map of 2001 by RWS-AGI, including the pioneer zone > 0.1 %.

6. Oosterschelde (K2)
P-REF-acreage 6 = 1,000 ha.
Potentially, a reasonably sheltered area such as the Oosterschelde should contain a substantial acreage of salt marshes, in the order of 3-5% of the total acreage. As the Oosterschelde is a system relatively poor in silt the lower boundary may be taken of 3% = 1,000ha.

P-GES-acreage 6 = 500 ha (including the pioneer zone > 0,1 %).
We assessed the acreage Reference Condition for P-GES at the ecological minimum acreage.
The total acreage of salt marshes in the 'big' Oosterschelde has been reduced with $^{2}/_{3}$ due to the construction of the storm-surge barrier and the compartmenting, due to which only 523 ha of salt marshes remained in 2001. The share of salt marshes is with 1.5 % of the intertidal area a very low value in comparison with other tidal basins. Moreover, salt marsh erosion will continue and compensation by accretion elsewhere in the same tidal basin is not to be expected as (1) the accretion had stopped more or less after 1870, (2) the (sub-) waters with the best preconditions for accretion have been embanked (Krammer-Volkerak and part of the eastern basin) and (3) since the completion of the storm-surge barrier in 1986 a shortage of sediment has existed and the erosion by waves has increased.

f) Brackish salt marshes Westerschelde

The historical Reference Condition after the introduction of rice grass was approx 10 % of the then tidal basin with 3,644 ha (similar to the Dollard). The present salt marsh acreage of 2,395 ha means a share of 7.7 % of the total tidal basin (likewise similar to the Dollard; Table 2.4 and 2.6). The Westerschelde is a water system with a high sediment load, presently still being high. Therefore this percentage may be used for the current situation. Though currently, there is a very lopsided distribution over the area, as the largest acreage is situated east of Hansweert and almost consisting of one continuous area. This does not benefit the variation along the salinity gradient and the robustness with regard to dynamics.

Westerschelde (sub-)water body 8	Historical reference (= % salt marshes 1938-1960)	Present acreage of salt marshes		Difference with historical reference	
Water type O2	%	ha	%	%	ha
Dutch Westerschelde =approx 31,000 ha at present	approx 10	2.395	7.7	-2.3	approx-700

Table 2.6 Salt marsh acreage in the Westerschelde in comparison with the reference condition (2.3.6). Salt marsh acreage of the Westerschelde based on Van der Pluijm & De Jong (1998) and the vegetation map of 1998 by RWS-AGI, including the pioneer zone > 0.1 %.

8. Westerschelde (O2)
P-REF-acreage 8 = 3,100 ha (including the pioneer zone > 0,1 %), of which a minimum of 25% west of Hansweert. If we compare the present acreage to the historical Reference Condition, then 700 ha of salt marshes are lacking.

P-GES-acreage 8 = 2,300 ha, of which a minimum of 500ha west of Hansweert. The share of salt marshes with 7.7 % of the intertidal area is relatively high, similar to the Dollard. It deserves the predicate of "Good Ecological Status". Therefore, P-GES becomes the present acreage–5%; 5% is required to build in some margins with respect to the dynamics that have to be present at the salt marsh's seaward edge. An extra requirement is that at least the ecological minimum acreage (500 ha) should lie west of Hansweert.

2.4.3. Summary of the values P-REF and P-GET

The table below shows a summary of the values for P-REF and P-GES for the various salt marsh types and water types. In the next section measures are elaborated upon that may contribute to the solution of bottlenecks.

SUB-AREA	PRESENT	P-REF	P-GES	REMARK
1 North Sea (K3 and K1)	544	Number of locations 2 per water type[11])	Number of locations 1 per water type	No further criterion for acreage
2 Wadden islands. West (K2) **4 mainland. NH + FRW (K2)** **2 + 4 TOTAL**	301 71 372	ecological minimum acreage per salt marsh type **1,000**	ecological minimum acreage 2 salt marsh types together **500**	- shortage - shortage
3 Wadden islands East (K2) **5 mainland. FRE + GR (K2)** **3 + 5 TOTAL**	2,852 2,310[12]) 5,162	2,800 6,550 **9,350**	2,000 2,600 [13]) **4,600**	- hydrodynamics have returned; - good distribution on the mainland, 1/3 part at a minimum in Groningen
6 Oosterschelde (K2)	523	Unknown	**500**	Erosion causing shortage shortly
7 Dollard (O2)	741	**1,000**	**700**	Erosion causing shortage shortly.
8 Westerschelde (O2)	2,395	**3,100**	**2,300**	Ecological minimum acreage 500 ha west of Hansweert

Table 2.7 Summary of the current acreage, potential Reference Condition (P-REF) and potential Good Ecological Status (P-GES) (in ha) for the salt marsh acreages per (sub-)water body (including the pioneer zone > 5 % for the Wadden Sea and including the pioneer zone > 0.1 % for the SW of the Netherlands).

2.4.4. *Metric Salt marsh acreages*

The indicated P-REF and P-GES above are to be converted into a metric for salt marsh acreage. To this end, we have set up a simple classification for the categories below P-GES in: <25% below P-GES; 25-50% below P-GES and >50% below P-GES, for Moderate, Poor and Bad respectively. In table 2.8 we indicated for each (sub-)water body what it scores on this metric. Most (sub-)water bodies score (still) within P-GES, beit that most are on the borderline.

[11]) If the entire coast will be classified as one water type P-REF becomes 4 locations and P-GES 2 locations

[12]) 1,511 ha salt marsh reclamation works + 700 ha farmland salt marshes + 100 ha NE Friesland. Without the pioneer zone (neither included in P-REF and strongly fluctuating from year to year; estimated at 400 ha)

[13]) 1,400 ha reclamation works + 700 ha farmland salt marshes + 100 ha NE Friesland + 400 ha pioneer zone > 5 % cover.

	P-REF	P-GES	moderate	poor	bad
K2/O2	See water body	See water body	<25% below P-GES	25-50% below P-GES	>50% below P-GES
K1/K3, North Sea coast	2 slufters/ water type ###	1 slufter/ water type	0 slufters/ water type		
Wadden Sea west;	1,000	500	500-375	375-250 ###	>250
Wadden Sea-east	9,350	4,600 ###	4,600-3,450	3,450-2300	>2,300
Oosterschelde	??	500 ###	500-375	375-250	>250
Ems/Dollard	1,000	700 ###	700-525	525-350	>350
Westerschelde	3,100	2,300	2,300-1,725 ### *)	1,725-1,150	>1,150

Table 2.8. Metric salt marsh acreage, Ka, per (sub-)water body in K and O2.
###: place of (sub-)water body on the metric
*): moderate with respect to the extra requirement that a minimum of 500ha must be situated west of Hansweert

2.5 Possible management measures to achieve P-GES

2.5.1. Restoration acreage salt marshes?

Some (sub-)water bodies do not reach the potential Reference Condition (P-REF) for acreage. In a number of water bodies P-REF actually cannot be determined due to essential changes in the geomorphologic preconditions and no P-REF has been selected. In addition to P-REF we include a potential Good Ecological Status (P-GES). This is not reached in several (sub-)water bodies likewise, or is threatening to turn out lower shortly due to continuous salt marsh erosion. In some cases the ecological minimum acreage of 500 ha has been applied for P-REF and/or P-GES. In this section we describe what options are available in order to achieve or preserve Good Ecological Status (P-GES). Finally, extra requirements have been made incidentally to the distribution of salt marshes over a (sub-)water body. For this as well we describe possible options in order to meet these requirements.

2.5.2. Passive approach by "exchanging" acreages

"Exchange" of acreages **between** the eight (sub-)water bodies in order to achieve the acreage reference condition per (sub-)water body is not advisable in principle, in view of the specific differences in geomorphology, soil composition and vegetation. "Exchange" of acreages **within** parts of (sub-)water bodies (between the various salt marshes) may be a passive opportunity to reach the acreage Reference Condition. **(a)** "Exchange" of acreages **within** a sub-area. This will only be possible for salt marshes within the **Westerschelde (500 ha rule)** and for the **mainland salt marshes of**

the provinces of Groningen and Friesland (500 ha rule). The latter currently is applied in the Salt Marsh Preservation Plan of Rijkswaterstaat District Wadden Sea with the condition that at least 1/3 of the acreage should be situated in one of the two provinces.
(b) "Exchange" **between** (sub-)water bodies or **joining** of sub-areas. The former might be considered for the **Wadden islands**, although this would devalue the specific character of each island. Moreover, the "surplus of salt marsh acreage" of 1,900 ha in the eastern Wadden islands does not cover by far the "lack" of 630 to 8,230 ha in the western Wadden Sea. It is more important to apply the vast acreage in the 'eastern' island salt marshes to have **natural dynamics** play a larger role on the islands. This would benefit the quality of the salt marshes (see Ch.3). A larger acreage is required for more natural dynamics as this means that vegetated areas may disappear (temporarily). Joining of (sub-)water bodies has been proposed for P-REF and P-GES in the western Wadden Sea.

2.5.3. An active method outside the dikes

(c) New "reclamation works". Traditional "reclamation works" in the Wadden Sea and in the southwest of the Netherlands were based on the stimulation of natural processes. Geomorphologically simple salt marshes formed with a natural vegetation cover. Without these interventions the current lack of salt marsh acreage would have been excessive. A very good management measure to increase the quality Reference Condition (requirement of the KPD Wadden Sea and international agreements) is making existing "reclamation works" more natural on the condition that the salt marsh acreage is not allowed to decrease and moreover it is reference-neutral as far as the acreage is concerned. New "reclamation works" are not a first option, as this means that one kind of nature outside the dikes (high tidal flats) is replaced by a different kind. At worst it should be debatable, in view of the positive experiences with the current "reclamation works".
Dumping soil in the area outside the dikes is a method that has been mentioned as an option frequently, but it is no serious option from the point of view of salt marshes. This technique causes that the wrong material is applied at the wrong place in the wrong shape, which damages the Reference Condition of quality. A salt marsh is the result of interactions between geomorphologic, physical and biological processes and is not the same as a vegetated pile of mud outside the dikes (Bakker et al. 1993). This option should not be debatable.

2.5.4. Two active methods within the embankments

(d) The removal of seaward dikes in the summer polders is the simplest option to restore the acreage Reference Condition. The measure adds simply salt marsh acreage without replacing nature outside the dikes. Experiences so far are positive with regard to the pace of the developments and the quality of the salt marsh thus formed (Van Duin et al. 1997, 2003). The "Sieperdaschor" at Saeftinghe is an example of a successful removal of dikes in the Westerschelde (Bakker et al. 2003). A complete restoration of the acreage **of Friesland mainland salt marshes** to more than the acreage Reference Condition is gradually being put into practice with this measure. The removal of seaward dikes of summer polders is a nature target in itself and cannot lead to the rejection of reclamation works based on the formulated KPD-policy.

(e) The removal of seaward dikes of polders behind Delta-dikes is a measure with little public support and it is very expensive. A condition is that there is adequate supply of sediment, based on which the **Oosterschelde** is dropped. It appears to be the only measure with which in the **western Wadden Sea** and in the **western Westerschelde** something may be achieved. In combination with a contribution to the drainage of the hinterland and with saline agriculture it might be possible to design a feasible form of removal of seaward dikes.
The creation of saline vegetations behind the dikes in polders that are prone to saline seepage is a method that is often considered an alternative for the complete removal of the seaward dikes. To this end a connection is made by the construction of a limited drain or by seepage pipes between the area within the embankments and the saline/brackish open water. Saline vegetations that originated this way cannot be considered to be an alternative for salt marshes, as the complex geomorphologic, physical and biological processes that are typical of a salt marsh and that form an essential part of a salt marsh are completely ignored.

2.5.5. Elaboration per (sub-)water body/salt marsh type

Below we indicate in short for the eight (sub-)water bodies how a minimum P-GES-acreage can be preserved or achieved.

a) Type North Sea coast

(Sub-)water bodies 1: Slufters and green beaches (water types K1 and K3). An important problem in this category is the sustainability. Many of this type of area tend to silt up, they require periodic maintenance. The total size of the area and the average height of the surface level play an important role in this. The current efforts to enlarge the Slufter on the island of Texel are very positive for the enhancement of the sustainability of the open link to the North Sea. The latter often is a problem, but in the case of the Slufter on the island of Texel all goes well with an acreage of approx 250 ha. The Zwin also having a total of approx 250 ha is having continuously problems with the maintenance of the sustainable link to the sea due to the huge sand supply along the coast. Here it is tried as well to fight the problem of silting up by extending the acreage.

b) Type Sandy Island salt marshes

Sub-areas:
(Sub-)water bodies 2. Wadden Islands west of the Terschelling tidal divide (water type K2). P-GES 2 + 4 = 500 ha. The islands (2) and the mainland west of Terschelling (4) can be added to calculate the ecological minimum acreage for the (sub-)water body as a whole (**method b**). In order to reach this minimum acreage all activities that may hamper possible recovery are to be refrained from. In addition a solution has to be found for the enormous shortage of salt marshes, for instance by removal of the seaward dikes on the island of Texel combined with the improvement of fresh water management and with saline agriculture (**method e**) and with finding out whether the contribution of the Kroonspolders on the island of Vlieland may be increased any further. Already 1/3 of the acreage is situated in the Kroonspolders.

(Sub-)water bodies 3. Wadden islands east of the Terschelling tidal divide (Water type K2). P-GES 3 = 2,000 ha, this is approx 2/3 of the current salt marsh acreage. Here ample salt marshes are present. The free space in the acreage offers opportunities to promote the dynamic processes on the eastern Wadden islands by removing actively (parts of) entrapment dikes.

c) Type Mainland salt marshes rich in silt

Sub-areas:
(Sub-)water bodies 4. Mainland Noord-Holland and Friesland up to the Terschelling tidal divide (water type K2). P-GES 4 + 2 = 500 ha (including the pioneer zone > 5 %). The mainland (4) and the islands (2) in the western Wadden Sea may be added to calculate the ecological minimum acreage (**method b**). In order to reach this minimum acreage all activities that may hamper possible recovery are to be refrained from. Some recovery is occurring at the moment naturally in the Slikhoek on the Balgzand; no intervention should be considered there (no promoting of accretion), as in this sheltered corner natural salt marsh development is possible. Furthermore, look for a solution to the enormous shortage of salt marsh acreage, possibly partly by compensating in the areas to be searched in such as Amstelmeer (make it brackish via the Balgzandkanaal; Wintermans & Dankers 2003), surroundings of Harlingen (removal of seaward dikes combined with an improvement of the drainage of the hinterland and with saline agriculture) and the Afsluitdijk (brackish intertidal area in combination with a third means of drainage) (**method e**). It is essential in these removals of the seaward dikes that it should be a matter of recovery of the total physical and geomorphologic processes. Possible compensation by a limited form of "reclamation works" off the Westhoek (Friesland) should be debatable as the sediment supply is exceptionally high, while natural salt marsh development seems to be impossible in this exposed site (**method c**).
(Sub-)water bodies 5. Mainland Friesland and Groningen east of the Terschelling tidal divide (Water type K2). P-GES = 2,600 ha (reclamation works with 1,400 ha of salt marshes and 400 ha of pioneer zone > 5 % + 700 ha farmland salt marsh + 100 ha NE Friesland). P-REF 5 = 6,540 ha (without pioneer zone). Based on the big difference between P-REF and P-GES the current policy for the Wadden Sea is to make the reclamation works more natural **without** loosing salt marsh acreage. The acreage-reference in Friesland will be achieved with removal of seaward dikes of summer polders (**method d**).The removal of seaward dikes of summer polders is a nature target in itself and will not lead to the rejection of reclamation works based on the formulated KPD-policy. A complete recovery of the salt marsh acreage for the province of Groningen is not realistic. The present acreage of reclamation works is continuous per province and per area well over the ecological minimum acreage. It remains necessary though, to continue maintenance of the brushwood dams of the reclamation works, as protection against erosion, in order to make a more natural management under the precondition of the preservation of salt marsh acreage and in order to maintain the pioneer zone (Dijkema et al. 2001).

d) Type Saline salt marshes:

(Sub-)water body 6. Oosterschelde (Water type K2). P-GES 6 = 500 ha (incl. pioneer zone > 0.1 %). The acreage Reference Condition has been determined to be the ecological minimum acreage. Recovery to P-REF is not realistic as the geomorphologic preconditions have been essentially changed. Therefore in the Oosterschelde all activities that may hamper possible recovery of salt marsh acreage are to be refrained from. A solution to the erosion problem should be looked for now as the salt marsh acreage will come below the ecological minimum acreage undoubtedly, due to bluff erosion. The geomorphologic preconditions are inadequate to compensate for by "reclamation works" (**method c**) and by removal of the seaward dikes(**method e**). **Bottleneck will turn up shortly!**

e) Type Brackish salt marshes

(Sub-)water body 7. Ems-Dollard (Water type O2). P-GES 7 = 700 ha (including pioneer zone > 0.1 %). Despite the historically determined lack of approx 300 ha the share of salt marshes is relatively high (7.5 % of the intertidal area, similar to that of the Westerschelde) and the acreage is well above the ecological minimum acreage, but almost at P-GES. Look now for a solution to the erosion problem, as the salt marsh acreage will come below P-GES **shortly** due to bluff erosion. Possibly compensation by a limited form of reclamation works (**method c**) and/or by removal of seaward dikes combined with an improvement of the drainage of the hinterland and saline agriculture (**method e**).

f) Type Brackish salt marshes

(Sub-)water bodies 8. Westerschelde (Water type O2). P-GES 8 = a total of 2,300 ha, approx 500ha (= ecological minimum acreage) of which west of Hansweert. We have taken the present acreage - 5 % **for the Westerschelde. A bottleneck is** that the current acreage in the mouth an in the central part of the Westerschelde is only approx 300 ha, distributed over many small locations. Therefore P-GES based on distribution is not reached. In the mouth and in the central part of the Westerschelde all activities that may hamper a possible recovery of salt marsh acreage are to be refrained from. Look for a solution to the completely lopsided distribution of the salt marshes: the possibilities are removal of seaward dikes in combination with saline agriculture (**method e**) and/or a limited form of "reclamation works" (**method c**).

2.5.6. Salt marshes and sea level rise

Salt marshes are in addition to internationally highly valued scenery a **natural foreshore to our sea dikes**. In the German Wadden Sea salt marshes are therefore regarded as part of the coastal protection (Niedersachsischer Landesbetrieb für Wasserwirtschaft und Küstenschutz, Betriebsstelle Norden 2003). Wave height measurements on the German coast during storm surges in areas with and without foreshores support this approach. In the Netherlands the function of salt marshes as coastal protection is not acknowledged as the dikes are higher than in Germany. By natural silting up the protection by salt marshes keeps pace with the sea level rise and with subsidence. Salt marshes are able to follow a possible accelerated sea level rise or subsidence by the combination of natural silting up and vegetation. In the past figures of 50 cm per century (0.5 cm per year) on the wadden islands and of 100 cm per century (1 cm per year) for the mainland coast have been mentioned (Dijkema, K.S. et al. 1990; Dijkema 1994, 1997). Based on the research into the effects of subsidence on the island of Ameland double values qua silting up during several decades seem to be possible (Eysink et al. 2000). In the Westerschelde sedimentation velocities of 1-2 cm per year have been measured (Stapel & de Jong, 1998). As far as sea level rise is concerned no problems are to be expected in the short run here. In the

Oosterschelde, however, recently it has been ascertained that the pace of sedimentation has been halved to 0.1-1 cm per year at a minimum (van Maldegem & de Jong, 2003). This means that here problems may arise in the case of an enhanced sea level rise.

The figures mentioned above are valid for the salt marsh zone. In the **pioneer zone** problems may arise however, even without sea level rise and subsidence. Due to a much thinner vegetation cover (and consisting mainly of annuals) there is little protection of the settled sediment in the pioneer zone, and due to that usually much less silting up. Eventually this difference in silting up between the pioneer zone and the salt marsh may cause bluff erosion of the salt marsh, i.e. the salt marsh keeps silting up in height, but the acreage is attacked from the seaward side by lateral erosion. In the reclamation works techniques for the support of nature have been developed in order to solve this problem: little dams of brushwood (sheltering against waves and current) and possibly a more intensive drainage (naturally via creeks). There is one but: in the case of a sea level rise of over 50 cm per century causing the tidal flats to subside or to vanish (as the Integral Subsidence Research Wadden Sea predicts) then simple management methods in the pioneer zone will not work in the long run. In that case we can fall back on a rough remedy: the salt marsh itself can be protected by a pitching, in which the exchange of water and sediment via creeks may not be hampered (QSR Wadden Sea 2005); see the examples of Punt van Reide and similar to it Halligen in the German Wadden Sea. In the Oosterschelde as well various smaller salt marshes have been protected against erosion by pitchings (Zijpe, Anna-Jacobapolder-west). Recently a small part of the salt marsh (Anna-Jacobapolder-northwest) has been protected with riprap.

3. REFERENCE CONDITION QUALITY FOR SALT MARSHES

3.1 Introduction

The aspect of quality in the WFD is aimed at the species composition and abundance (degree of occurrence). Within a salt marsh only a limited number of plant species play a part. These species occur usually in limited (height) zones in a salt marsh, and within these zones mainly as dominant species that are typical of a number of important vegetation types. Moreover, local differences in the salt marshes (sandy-rich in silt, saline-brackish, southern-northern) are restricting further the number of species that actually occur in a salt marsh or (sub-)water body. Therefore, we are using vegetation zones here instead of species. They represent the botanical structure of a salt marsh.

3.2 Zoning and succession of salt marsh vegetation

In addition to the acreage of salt marshes, the composition of the vegetation is important as well. In general a salt marsh may be divided into a number of zones, from the pioneer zone in the lowest parts via the low and middle high salt marsh to the high salt marsh (Figure 3.1). These zones usually represent both the altitude zoning within a salt marsh and the development in the process of succession.

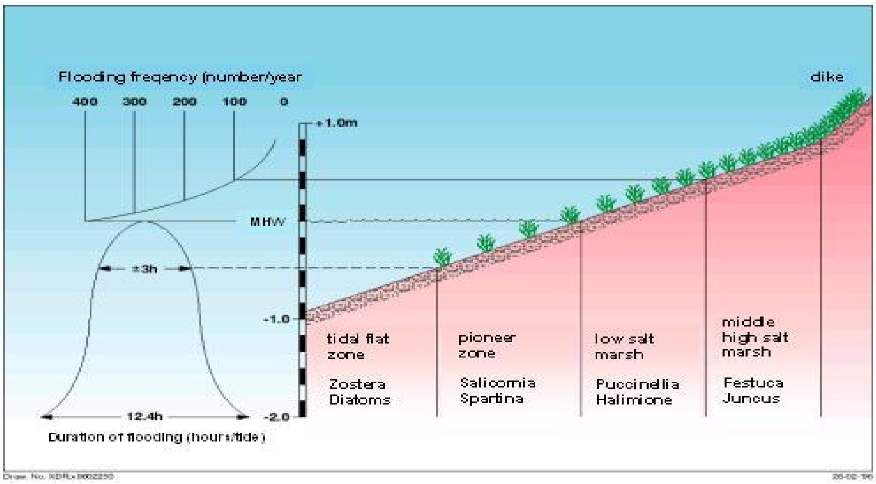


Figure 3.1 Altitude, flooding frequencies and zoning of the salt marshes in the Wadden Sea. After Erchinger 1985.

A salt marsh usually starts as a pioneer vegetation. Due to sedimentation the pioneer zone changes into the low, middle high and high zone, while the vegetation changes along with it by succession. On the sand flats of the Wadden islands (e.g. Bosplaat on Terschelling, De Hon on Ameland, Oosterkwelder on Schiermonnikoog) an altitude zoning is present from the initial stage of sedimentation, due to the increasing height into the direction of the dunes of the originally bare sand flat and in those cases the zoning does not represent the process of salt marsh development.

Even from the low zone onward, vegetation on a salt marsh in the Wadden Sea may develop into a climax vegetation, when a clay-layer of over 15 – 20 cm (Bakker 1993) has formed and there is no grazing. When a salt marsh has become very high, (part of) it will usually start to erode, after which the cycle restarts with the generation of a pioneer zone. A single salt marsh may find itself just at the beginning or at the end of this cycle, but within all salt marshes in a water system as a whole there should be a certain balance between the shares of the various zones. Strong overrepresentation of one zone or of one climax-vegetation generally indicates a disturbance of the cyclic processes within the water system. This means that the diversity within vegetation zones and vegetation types should be well balanced. One or several vegetation types or vegetation zones must not dominate the salt marsh. This fact will be developed below into the metric for salt marsh quality.

3.3 Distribution of vegetation zones in salt marshes

So, within a salt marsh only a limited number of plant species play a role, which partially mainly dominate certain vegetation types. Therefore, we are working with the vegetation zones of pioneer, low, middle high and high instead of with species in the development of a quality metric. In addition we are discerning two climax vegetations in the brackish zone, climax reed (in brackish areas) and climax sea twitch (in saline or brackish areas respectively). The acreages of the vegetation zones have been quantified by RWS-AGI for SW Netherlands based on the vegetation classification Salt97 (De Jong et al. 1997) and for the Wadden Sea based on the TMAP-classification for the international Wadden Sea-monitoring. The key to the contents of the zones is given in appendix 1. The acreages have been calculated based on the net acreage a zone takes up. This means that when in a particular part of the map two zones are occurring with e.g. 40 and 60 % respectively the acreage of that part of the map is distributed according to this key over the zones present. For example : in an area of 1.5 ha 40% zone 1 and 60% zone 2 are occurring; then zone 1 (40% van 1.5 ha) gets an acreage of 0.6 ha and zone 2 (60% van 1.5ha) one of 0.9 ha.

Climax vegetations can dominate strongly when a salt marsh reaches its end stage. Both climax vegetations yield systems poor in species that are not advisable from the point of view of nature conservation when they would dominate an area or water system (Bakker var. public., Storm 1999, Esselink 2000, Dijkema et al. 2001). Grazing (by geese and hares) may postpone the development of a climax vegetation or may even prevent it (by cattle). A too intensive a grazing, conversely, may keep the salt marsh at a young stage with few species, due to which a salt marsh is not able to develop naturally. The current economic development in agriculture causes decreased grazing of the reclamation works. In view of the age and height of the greater part of these mainland salt marshes this development has caused a strong expansion of one-sided vegetations with sea twitch, on the old farmland salt marshes sometimes with creeping thistle (Figure 3.2), in the past 20 years.

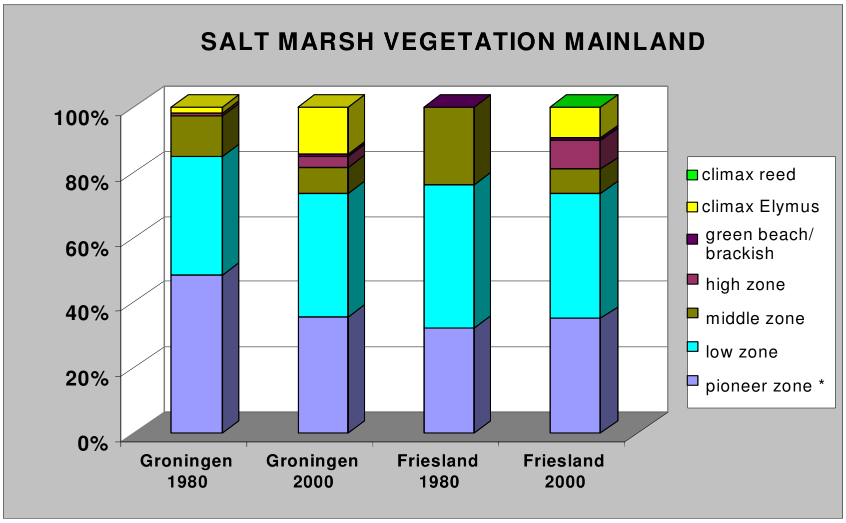


Figure 3.2 Overview of the share in terms of percentage of the various zones per water system. Based on vegetation maps MWTL(a Dutch monitoring program) by RWS-AGI, mapping years approx 1980 and 2000.

The varied saline vegetation on the salt marshes is disappearing. We are expecting this trend to continue (Dijkema et al. 2004).

Within a (sub-)water body a particular salt marsh may find itself mainly at the beginning stage or mainly at the end stage. But within a (sub-) water body as a whole the vegetation zones pioneer/low/middle high/high that are discerned must each be present in a reasonably balanced way, while climax vegetations on the contrary must not occur too often. This can be found as well in the function requirement on quality in the Salt Marsh Preservation Plan of Rijkswaterstaat District Wadden Sea . The SPP is an elaboration of the Management Plan Wadden Sea[14]).

Figure 3.3 gives a global overview of the share of the various zones per (sub-)water body for the year of monitoring 2000[15]). Appendix 2 depicts the information per (sub-)water body for the years of monitoring 1980, 1990 and 2000. Appendix 3 shows the elaboration per (sub-)water body per salt marsh for the year of monitoring 2000.

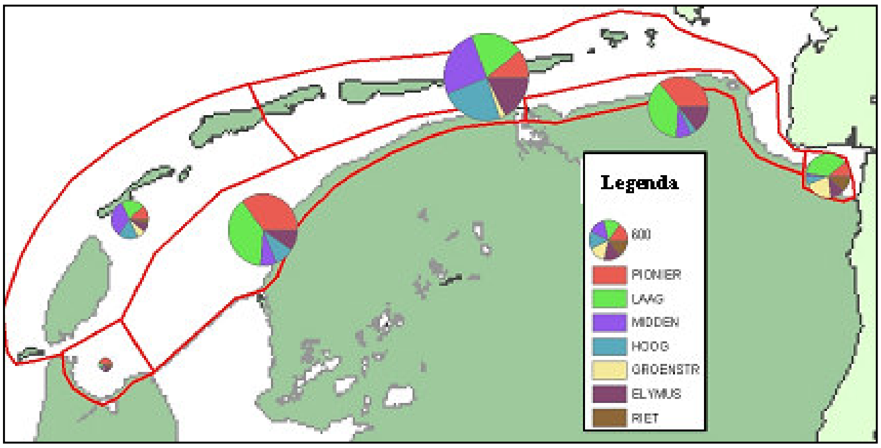
Some striking **conclusions** from Figure 3.3 and appendices 2 and 3 are:

1. On the one hand the distribution of vegetation zones proves to be very variable. In certain water bodies such as the eastern Wadden Sea and the Oosterschelde biodiversity even increases in the vegetation zones in the period 1980-2000.
2. On the other hand the acreage of climax-vegetation in the period mapped increased:

[14]) The Management Plan Wadden Sea 1996-2001, a joint document of three administrative tiers Government, Province and Municipalities, says on biodiversity:
"The management of salt marsh vegetations will only take place by grazing. The objective is a versatile vegetation structure with plant and animal species that belong in the wadden area by nature. No management takes place on behalf of species in particular."
Rijkswaterstaat has translated these results on behalf of the reclamation works into a function requirement:
"Diversity in the vegetation structure by grazing (if possible in large parcellation units) with an alternation of intensive (approx 35 %), moderate (approx 20 %), extensive (approx 20 %) and ungrazed (approx 25 %) areas. On average about 0.5 cattle-unit per ha per province is present, on the total of mature and young salt marshes."
[15]) Mappings occur spread in time; therefore the years 1980, 1990 and 2000 are years of monitoring with the mapping nearest in time taken per year of monitoring.

- In the southwest of the Netherlands sea twitch has increased manifestly. The period varies per site.
- In the Wadden Sea, sea twitch has increased along the Groningen north coast during the whole period 1980-2000.
- In the Wadden Sea, sea twitch has increased along the Friesland mainland coast and on the eastern Wadden islands between 1980 and 2000 (see Figure 3.3). The areas mentioned make up the greater part of the salt marsh acreage in the Wadden Sea.

In general, the prospect is that with the present salt marshes becoming older and the management remaining the same, the share of climax-vegetation will increase to a condition in which the diversity in vegetation zones will decrease. Publications on the Wadden islands (Bakker et al. various), on the salt marshes in the southwest of the Netherlands (Storm 1999), on reclamation works in the north of the Netherlands (Esselink 2000; Dijkema et al. 2001) and the monitoring of subsidence on the island of Ameland (Eysink et al. 2000) are all indicating it. The idea is being enhanced by the fact that the vegetation mapping keeps lagging behind the actual situation in the field two to six years due to the mapping cycle. The effects of the decrease of grazing of various salt marshes in the Wadden Sea in the past years have not yet become fully evident everywhere in the figures.



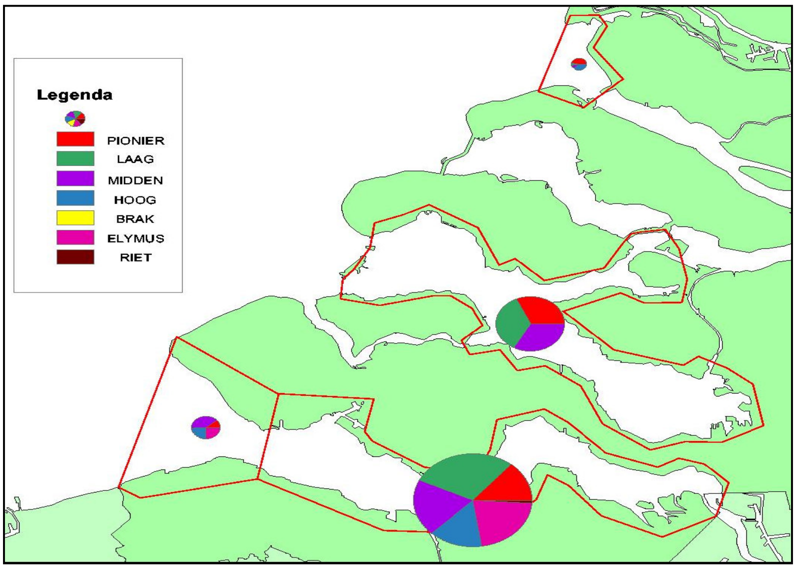


Figure 3.3 Overview of the share in terms of percentage of the various zones per water system. Based on vegetation maps MWTL by RWS-AGI, mapping years approx 2000.
Legend:
Pionier: pioneer
Laag: low salt marsh
Midden: middle salt marsh
Hoog: high salt marsh
Groenstr: green beach
Riet: reed
Brak: brackish salt marsh

3.4 Reference condition salt marsh quality

We developed a metric for the quality Reference Condition newly based on a comparison of the vegetation zones in the mapping years 1980, 1990 and 2000. The reference condition is based on the **assumptions** mentioned before:
1) within a (sub-)water body the vegetation zones pioneer, low, middle high and high are to occur in a balanced way; this means that their share in the total vegetation should not be too small and not too big.
2) climax-vegetations must not dominate within the vegetation zone in which they belong.
This can be quantified thus:
Sub 1) The various salt marsh zones are validated in the assessment on the percentage they take up of the total salt marsh acreage of a (sub-)water body. We use 5 % as limiting value for the lower boundary and 35 or 40 % for the upper boundary. If the percentage lies between the limiting values then the zone gets the assessment "good" (1); above or below them "bad"(0). The choice of which upper boundary is used, is determined by the number of zones that it included in the assessment of a particular(sub-)water body: in the case of 4 zones 40% and in the case of 5 zones 35%.
Sub 2) The acreage reed is at a maximum 50% of the acreage zones brackish + reed, and the acreage Elymus is at a maximum 50% of the acreage zones high + sea twitch.

Table 3.1 indicates which zones and climax vegetations per (sub-)water body are included (the brackish zone is not everywhere an essential part of the salt marsh).

(sub-)water body	zones	climax vegetation	boundaries	max. score
Dollard	P, L, M, H, B	Elymus, reed	5 – 35	7
W-Sea-east-islands	P, L, M, H, B	Elymus	5 - 35	6
W-Sea-east-salt marshes*	P, L, M, H	Elymus	5 - 40	5
W-Sea-west-islands	P, L, M, H, B	Elymus	5 - 35	6
W-Sea-west-salt marshes*	P, L, M, H	Elymus	5 - 40	5
W-Sea-west-N Holland	P, L, M, H	Elymus	5 - 40	5
Texel-North Sea	P, L, M, H, B	Elymus	5 - 35	6
Haringvliet-mouth	P, L, M, H	Elymus	5 - 40	5
Oosterschelde	P, L, M, H	Elymus	5 - 40	5
Westerschelde-mouth	P, L, M, H	Elymus	5 - 40	5
Westerschelde$	P, L, M, H	Elymus	5 - 40	5

Table 3.1. Vegetation zones included in the qualitative assessment of salt marshes per (sub-)water body.
P: pioneer zone; L: low salt marsh zone; M: middle high salt marsh zone; H: high salt marsh zone; B: brackish zone
NB: *:in the Wadden Sea salt marshes the pioneer zone vegetated <5% is not included as this can vary considerably from year to year and can only be mapped with difficulty (less reliably) in the reclamation works.
$: in Westerschelde also a part of the Belgian River Scheldt (Zeeschelde) should be included in order to get the zoning correctly, this means the brackish zone should be included in that case the maximum score becomes 7.

We scored each assumption; in the case of a positive score a 1 and in the case of a negative score a 0. For instance, if the pioneer zone in a (sub-)water body amounts to 15% this results in the score of 1, if it occurs in 3% then the score is 0. If the climax vegetation sea twitch does not dominate within the high zone concerned then it scores 1 and if it does, then it scores 0. The total score per (sub-)water body is used for the final assessment if the level of P-REF or P-GES is attained; table 3.2 shows the way of assessment is depicted in. Table 3.3 is the final scores table for the target year 2000. In appendix 4 we have worked out data for all three years of monitoring.

Assessment of quality	max score 5	max score 6/7
P-REF	5	7 / 6
P-GES	4 / 3	5 / 4
Moderate	2	3 / 2
Poor	1	1
Bad	0	0

Table 3.2. Assessment of the scores of salt marsh quality per (sub-)water body on behalf of the metric salt marsh quality.

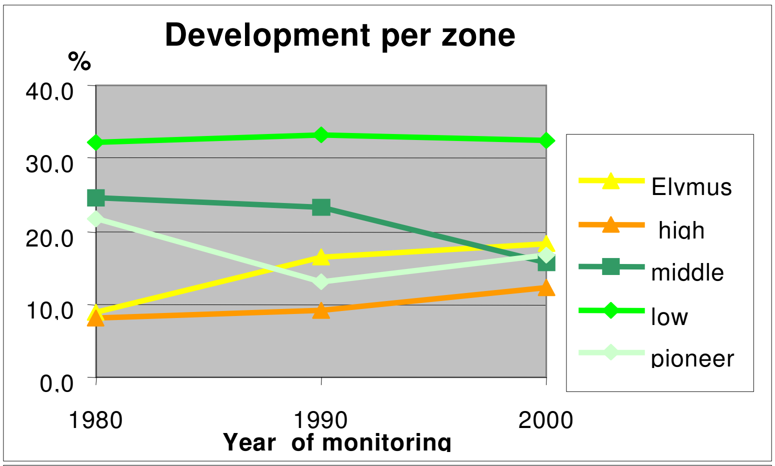
3.5 Results and conclusions of the assessment of salt marsh quality

From Table 3.3 we may conclude that the salt marshes in most water bodies are in good status, P-GES in the present situation. Taking the changes in the period 1980 – 2000 into account (see table 3.4), the score for the (sub-)water body as a whole seems to improve or to remain the same in many cases.
Taking the percentages for the whole of the Netherlands into account (Figure 3.4), we see that the pioneer zone often varies strongly, which is linked to the character of the vegetation and the dynamic circumstances, and the low zone remains reasonably stable. The acreage of the middle high zone steadily decreases, however, and the acreage high and sea twitch are steadily increasing. Figure 3.4-below, in which the strongly variable pioneer zone has been left out, shows it better still. This shift from middle high zone to high zone + sea twitch zone, in which the sea twitch zone in particular increases, indicates an aging of the salt marshes as a whole.
It indicates as well that at the moment there are few problems with the quality of the salt marshes, but that it will turn into assessments of moderate and lower in due time. We cannot indicate the term and it obviously varies per (sub-)water body. In view of the available information this might be the case very soon (within a decade) for several water bodies.

Area	pioneer	low	middle	high+ Elym.	brackish+ reed	Elym. >high	Reed >brackish	score	max. classes	Assessment
Ems-Dollard	1	0	0	1	1	0	1	4	7	P-GES
Wadden Sea-GR-salt marsh	1	1	1	1		0		4	5	P-GES
Wadden Sea-FR-salt marsh	1	1	1	1		0		4	5	P-GES
Wadden Sea -NH-salt marsh	0	1	1	1		0		3	5	P-GES
Wadden Sea -E-islands	1	1	1	0	0	1		4	6	P-GES
Wadden Sea-W-islands	1	1	1	0	1	1		5	6	P-GES
Texel-North Sea	1	1	0	1	1	0		4	6	P-GES
Haringvliet-mouth	0	1	1	0		1		3	5	P-GES
Oosterschelde	1	1	1	1		0		4	5	P-GES
Westerschelde-mouth	1	1	1	0		0		3	5	P-GES
Westerschelde	0	0	1	1		0		2	5	Moderate

Table 3.3. Salt marsh quality, score per zone/climax vegetation + total score and the assessment per (sub-)water body in the year of monitoring 2000 cf the metric salt marsh-quality. (Elym. = Elymus)

Zone not included



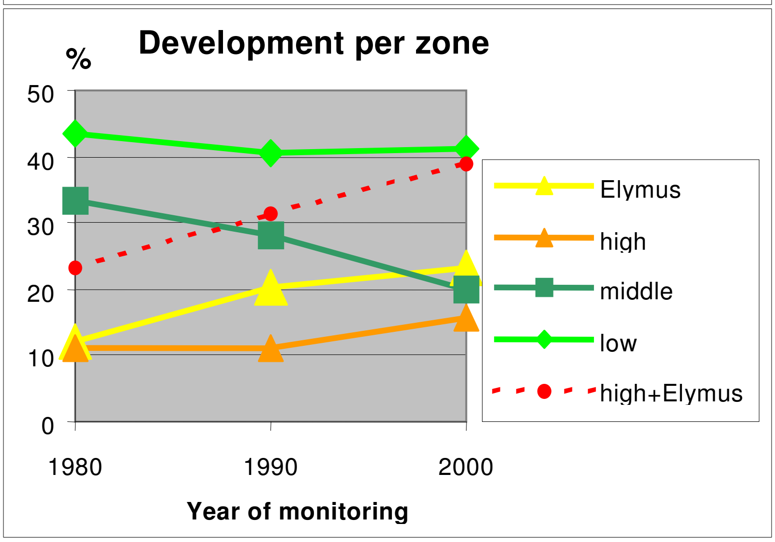


Figure 3.4. Total acreage per zone of all Dutch salt marshes together (exclusive brackish and reed, as these are included on a limited scale).
Top figure, including the pioneer zone

Bottom figure excluding pioneer zone

Sub-area	1980			1990			2000		
	score	classes	quality	score	classes	quality	score	classes	quality
O2 Ems-Dollard	3	7	moderate	3	7	moderate	4	7	P-GES
K2 Wadden Sea-GR-salt marsh *	2	5	moderate	4	5	P-GES	4	5	P-GES
K2 Wadden Sea-FR-salt marsh *	3	5	P-GES	4	5	P-GES	4	5	P-GES
K2 Wadden Sea-NH-salt marsh	4	5	P-GES	2	5	moderate	3	5	P-GES
K2 Wadden Sea-E-islands	4	6	moderate	3	6	moderate	4	6	P-GES
K2 Wadden Sea-W-islands	6	6	P-REF	6	6	P-REF	5	6	P-GES
K3 Texel-North Sea	3	6	moderate	3	6	moderate	4	6	P-GES
K1 Haringvliet-mouth	3	5	P-GES	3	5	P-GES	3	5	P-GES
K2 Oosterschelde	4	5	P-GES	3	5	P-GES	4	5	P-GES
K1 Westerschelde-mouth	2	5	moderate	2	5	moderate	3	5	P-GES
O2 Westerschelde	3	5	P-GES	2	5	moderate	2	5	moderate
the Netherlands in total	4	6	P-GES	4	6	P-GES	4	6	P-GES

Table 3.4 Assessment scores for the years of monitoring 1980, 1990 and 2000
(*GR: Groningen; FR: Friesland; NH: Noord Holland*)

Measures to counter it lie in the field of grazing and rejuvenation. The introduction or adaptation of both measures, rejuvenation in particular, are time-consuming and it will take a long time before they will be noticed in assessments. It seems advisable to analyse now already where and in what term problems are to be expected in the quality of salt marshes, and to consider already the nature of the measures that are most suitable to prevent a decrease of quality.

Glossary

Entrapment dike	artificial dune, initially made by placing rows of brushwood at the beach, thus entrapping sand to form ridges in the shelter of which quiet conditions form
IBN	former name of Alterra, institute of knowledge of the natural environment
KPD	Key Planning Decision
MWTL	set of ecological monitoring systems for fresh water
Nature target type	various types of ecosystems being realized in the Netherlands
Rugged coastline	in this case a coast in sediment with many barriers and inlets and salt marshes
Rijkswaterstaat (RWS)	Directorate-General of Public Works and Water Management of the Ministry of Transport, Public Works and Water Management.
RWS-RIKZ	National Institute for Coastal and Marine Management of Rijkswaterstaat
RWS-AGI	Geo-information and ICT Department of RWS
Salt97	classification system (and PC-program) of salt marsh vegetations
Sand hunger	after the construction of the storm-surge barrier the tidal volume has reduced by 30% and current velocities have reduced likewise. The channels are too big for the current situation and are trying to fill with sediment nearby
Slufter	sea inlet in a sandy coast line, lined by dunes and vegetated
TMAP	Trilateral Monitoring and Assessment Program
Wadden	a relatively wide area (generally separated form the open sea by a system of barrier islands) that is for the greater part covered by sea water at high tides, but uncovered at low tides
Wadden Islands	Dutch name for West Frisian Islands

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Appendices

Appendix 1. Classification of vegetation types in vegetation zones

FINAL VERSION SALT MARSH ZONES WFD (25 NOVEMBER 2003)

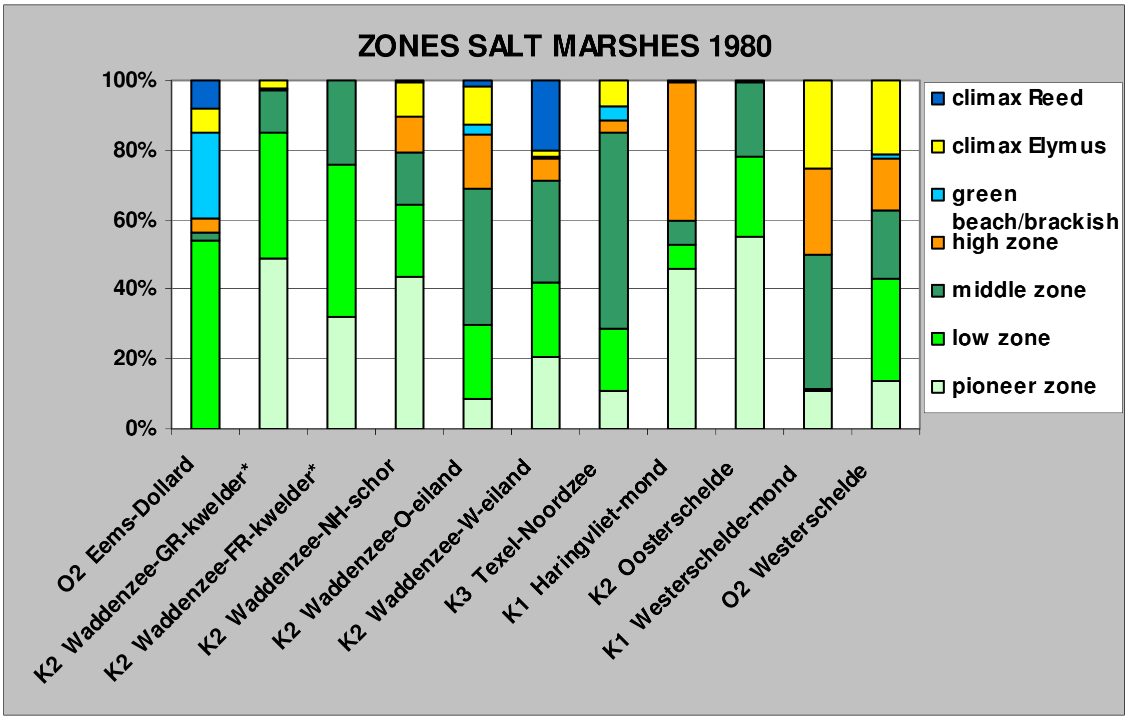
Brackish types discerned separately only on the Wadden islands and in the Dollard
Brackish transitions in the estuaries of the SW of the Netherlands integrated within all zones
-r types in zone of first letter
-b types brackish, except sea twitch types
--------: not included in a zone

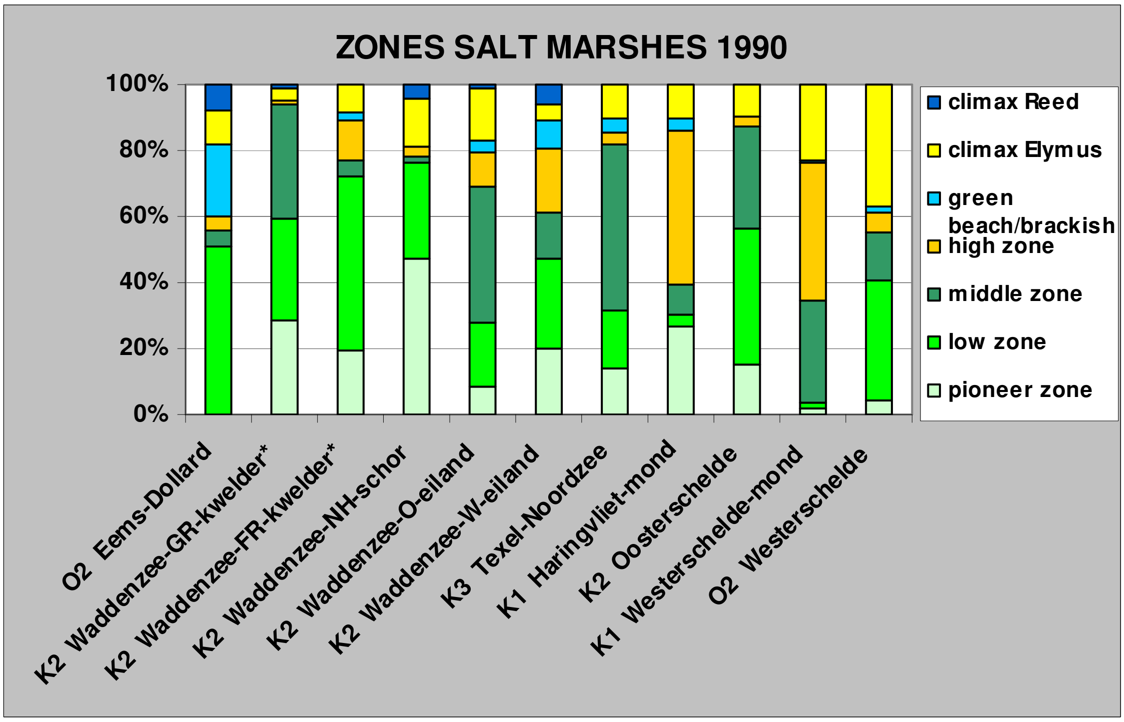
Pioneer zone
Low salt marsh
Middle high salt marsh
High salt marsh
Climax Elymus
Brackish salt marsh
Climax Reed

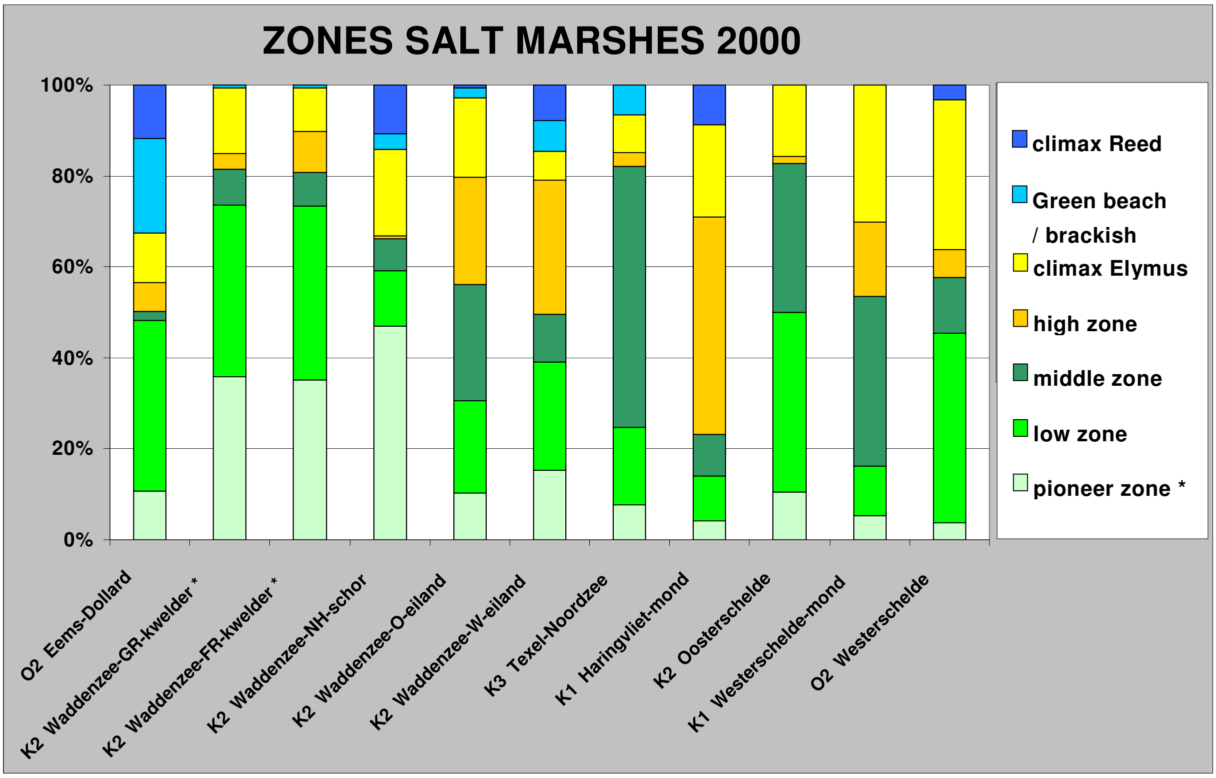
CODE	LOCAL TYPES	WFD-ZONE	WADDEN SEA	SOUtTHWEST NED.
Ba3		L	Low salt marsh	Low salt marsh
Ba5		L	Low salt marsh	Low salt marsh
Bb3		CR	Climax Reed	Climax Reed
Bb5		CR	Climax Reed	Climax Reed
Bg	BG-E, BG-F	B	Brackish salt marsh	High salt marsh
Bi3		B	Brackish salt marsh	Pioneer zone
Bi5	BI5Y	B	Brackish salt marsh	Low salt marsh
Bt		B	Brackish salt marsh	Middle high salt marsh
Cc	CC-I	H	High salt marsh	High salt marsh
Cr		H	High salt marsh	High salt marsh
Ee		H	High salt marsh	High salt marsh
Eei		H	High salt marsh	High salt marsh
Eep	EE-P	H	High salt marsh	High salt marsh
Jex	JEXS, JEXF, JEXG, JEXA	L	Low salt marsh	High salt marsh
Jf	JF-*, JFB, JF-G, JF-E, JF-P, JF-X	M	Middle high salt marsh	High salt marsh
Jfa		M	Middle high salt marsh	High salt marsh
Jfh	JFH5	M	Middle high salt marsh	High salt marsh
Jfl	JF-L	M	Middle high salt marsh	High salt marsh
Jfm		M	Middle high salt marsh	High salt marsh
Jf-r		M	Middle high salt marsh	High salt marsh
Jfz	JFZA, JFZB	M	Middle high salt marsh	High salt marsh
Jj	JJ-T, JJ-X, JJ-F, JJ-E, JJ-S	M	Middle high salt marsh	High salt marsh
Jja		M	Middle high salt marsh	High salt marsh
Jjl		M	Middle high salt marsh	High salt marsh
Jjm		M	Middle high salt marsh	High salt marsh
Jj-r		M	Middle high salt marsh	High salt marsh
P	P--B, P--I, P--S,	L	Low salt marsh	Low salt marsh
PE	PE-B, PE-B, PE-X		Middle high salt marsh	Middle high salt marsh
Pf	PF-A, PF-B	L	Low salt marsh	Middle high salt marsh
Pg		L	Low salt marsh	Middle high salt marsh
Ph3	PH3L, PH3S, PH-U	L	Low salt marsh	Middle high salt marsh
Ph5	PH5F	L	Low salt marsh	Middle high salt marsh
Pj		L	Low salt marsh	Middle high salt marsh
Pl3	PL3P, PLM	L	Low salt marsh	Middle high salt marsh

Pl-u		L	Low salt marsh	Middle high salt marsh
Pp	PP-M	L	Low salt marsh	Middle high salt marsh
Ppa		L	Low salt marsh	Low salt marsh
Ppab		B	Brackish salt marsh	Low salt marsh
Pp-b		B	Brackish salt marsh	Middle high salt marsh
Pp-e		H	High salt marsh	Low salt marsh
Ppl		L	Low salt marsh	Middle high salt marsh
Pplu		L	Low salt marsh	Middle high salt marsh
Pps		L	Low salt marsh	Low salt marsh
Ppsb		B	Brackish salt marsh	Low salt marsh
Pp-u		L	Low salt marsh	Middle high salt marsh
QQ0		P	-------	Pioneer zone
Qq3	QQ3E, QQ3P, QQ3-P,QQ3-E, QQ3A,	P	Pioneer zone	Pioneer zone
	QQ3B QQ3-A, QQ3-B		Pioneer zone??	Pioneer zone??
Qu	QU-A	P	Pioneer zone	Pioneer zone
Rdg		D	**Grass lands fresh**	High salt marsh
Rds		D	**brushwood fresh**	High salt marsh
R*	RDM, R-F, R--F, R--FE, R--FH, R--FL, RU, R--M, RJ--P,	H	High salt marsh	High salt marsh
	R--V, R--H, R-HOR, R--P, R—C, R--S, R--R, RN, R--E		Grass lands fresh???	Grass lands fresh???
R*	RD, RDG, RDO, RDRC, RDA, RDV		**Dune**	High salt marsh
Rg	RG-T, R-G, RG-I, RGJ, RG-J, RG-Q, RG-E, RG-H, RG-C	H	High salt marsh	High salt marsh
Rgf	RGF*	H	High salt marsh	High salt marsh
Rgn		H	High salt marsh	High salt marsh
Rgp	RGPF, RGPE	H	High salt marsh	High salt marsh
Rgv	RGV-A, RGV-B	H	High salt marsh	High salt marsh
Ri		B	Brackish salt marsh	High salt marsh
Rm	RM-C, RM-F, RM-P, RM-W	B	Brackish salt marsh	High salt marsh
Ro		H	High salt marsh	High salt marsh
Rra		D	**Dune**	High salt marsh
Rre		CE	Climax Elymus	High salt marsh
Rrl	RRX	D	**Dune**	High salt marsh
Rry	RRYC	CE	Climax Elymus	Climax Elymus
RRX		CE	Climax Elymus	Climax Elymus
SS0		P	-------	Pioneer zone
Ss3		P	Pioneer zone	Pioneer zone
Ss3b		B	Brackish salt marsh	Pioneer zone
Ss5		P	Pioneer zone	Low salt marsh
Ss5b		B	Brackish salt marsh	Low salt marsh
Xe5,		CE	Climax Elymus	High salt marsh
Xx5		CE	Climax Elymus	High salt marsh
Xx5b	XX3B	CE	Climax Elymus	High salt marsh
Xxk		H	High salt marsh	High salt marsh
Xy3	XY3R, XY3F, XY3J	CE	Climax Elymus	Climax Elymus
Xy3b		CE	Climax Elymus	Climax Elymus
Xy5	XY5A, XY5B, XY5F	CE	Climax Elymus	Climax Elymus
Xy5r	XY5R	CE	Climax Elymus	Climax Elymus
ELF		D	**Dune**	**Dune**

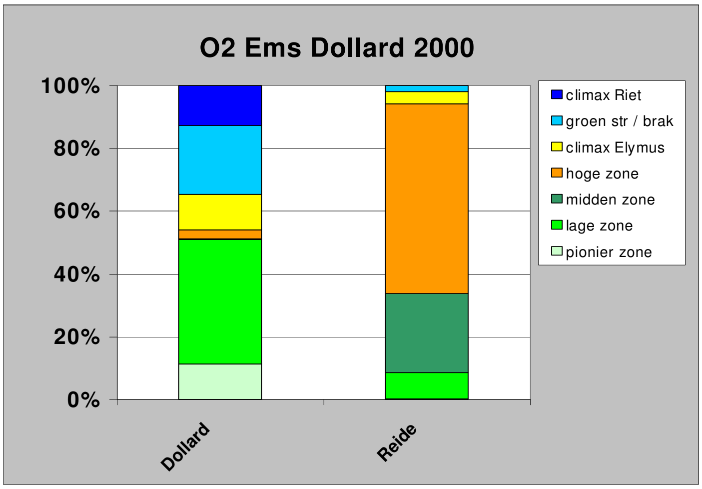
Appendix 2. Overview of the share in terms of percentage of the various vegetation zones per (sub-)water body based on vegetation maps (monitoring program), years of monitoring 1980, 1990 and 2000
* pioneer zone vegetated <5 %: acreage along Groningen and Friesland mainland from year to year extremely variable and therefore not depicted all over the Wadden Sea
High zone: exclusive sea twitch (Elymus); Brackish excluding reed
Oosterschelde 1980: deviating mapping technique causing acreage of pioneer zone to be overrated in comparison with later years; possible overrating approx 30-40%.
Legend X-axis: kwelder / schor = salt marsh ; Mond = mouth of estuary
Waddenzee = Wadden Sea ; Noordzee = North Sea ; Eems-Dollard = Ems estuary

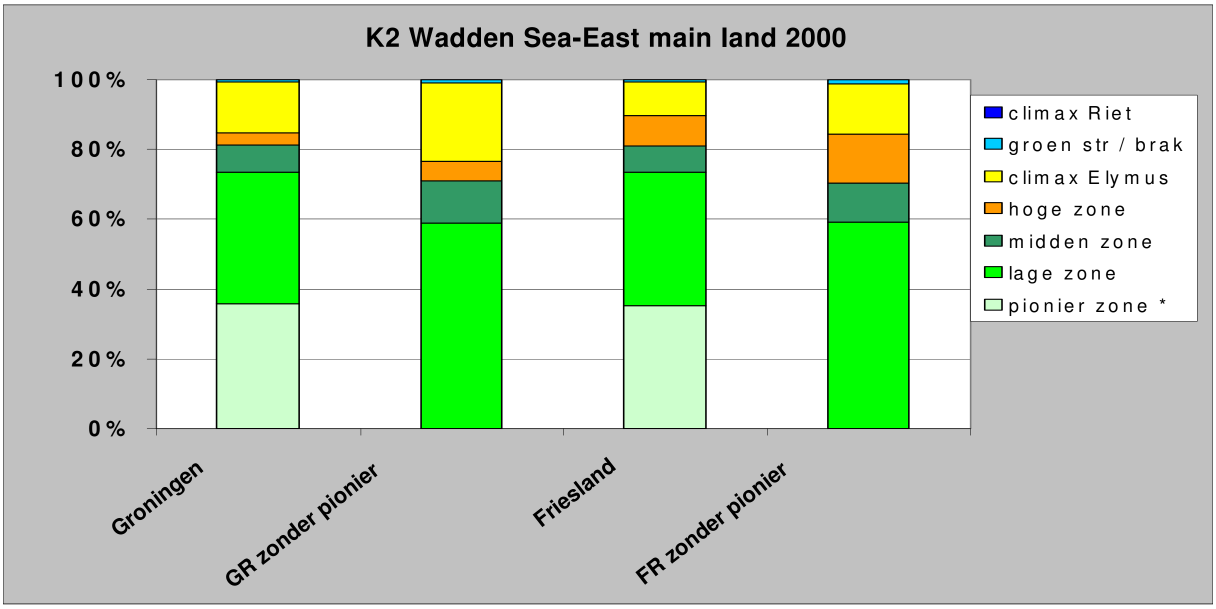


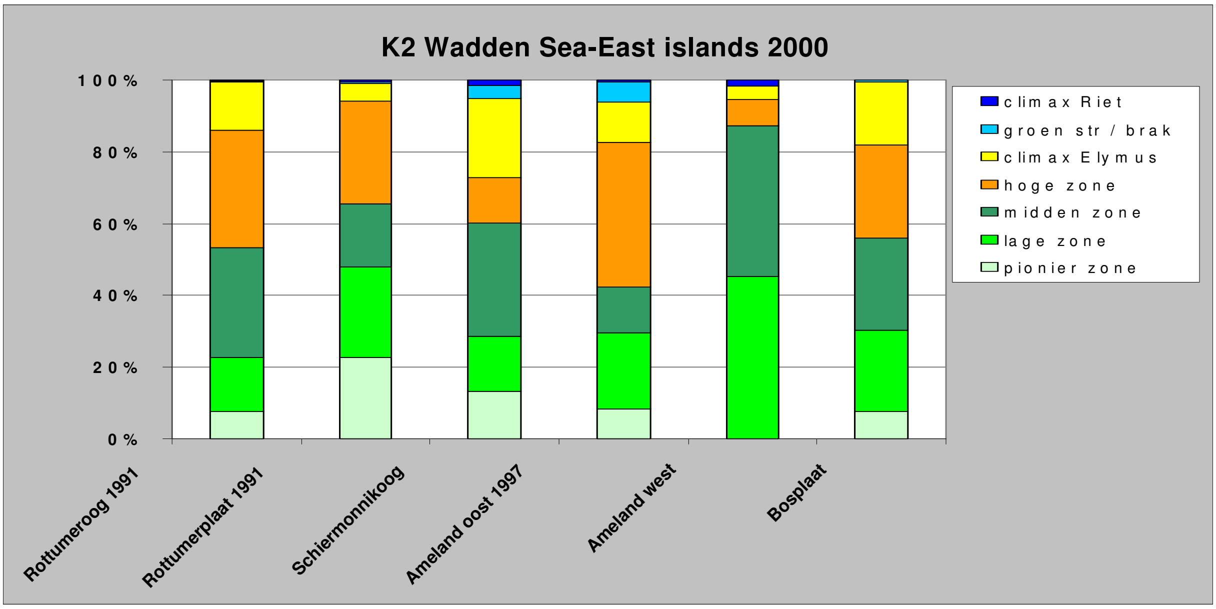


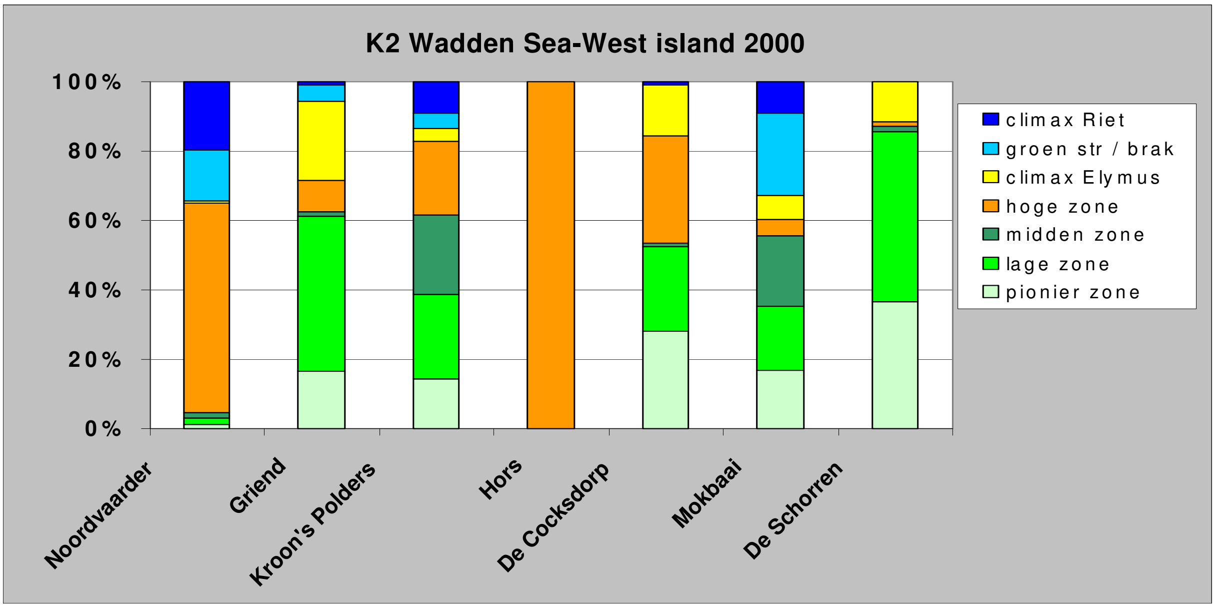

ZONES SALT MARSHES 2000
100%
80%
60%
40%
20%
0%
O2 Eems-Dollard
K2 Waddenzee-GR-kwelder *
K2 Waddenzee-FR-kwelder *
K2 Waddenzee-NH-schor
K2 Waddenzee-O-eiland
K2 Waddenzee-W-eiland
K3 Texel-Noordzee
K1 Haringvliet-mond
K2 Oosterschelde
K1 Westerschelde-mond
O2 Westerschelde
climax Reed
Green beach / brackish
climax Elymus
high zone
middle zone
low zone
pioneer zone *

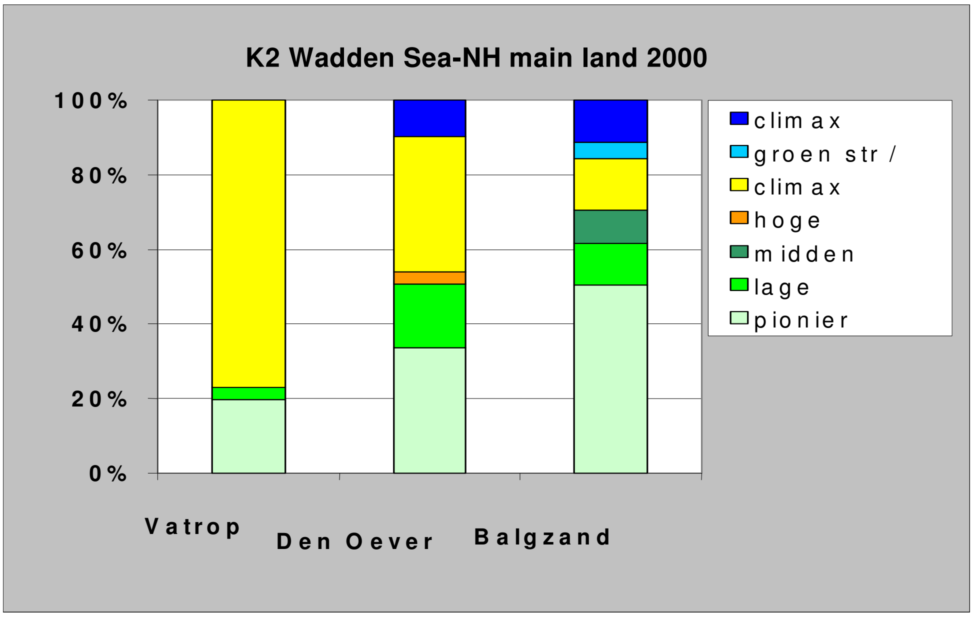
Appendix 3. Overview of the share in terms of percentage of the various vegetation zones per (sub-)water body based on the most recent vegetation maps (MWTL), year of monitoring 2000. (Legend see end Appendix 3)

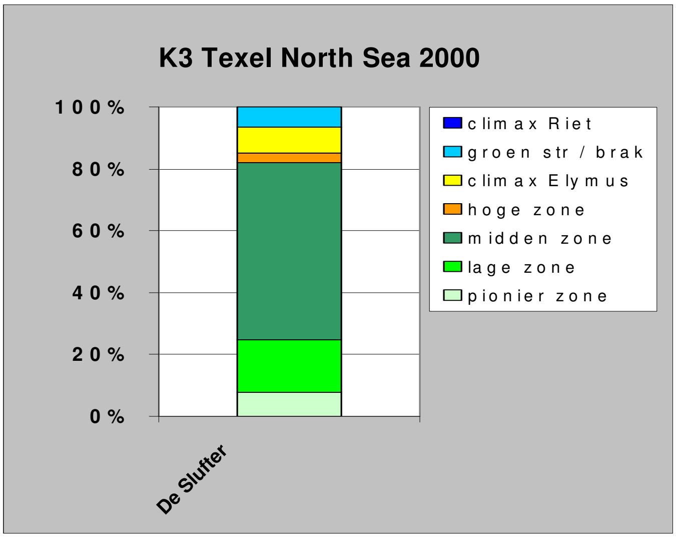


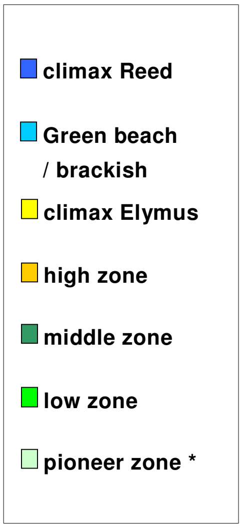


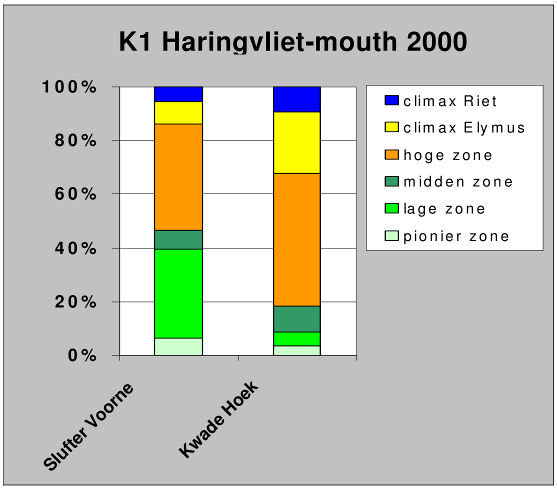


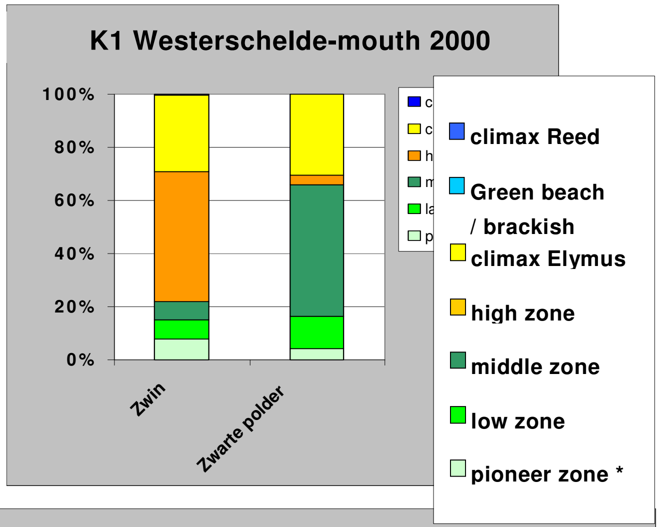

K2 Wadden Sea-West island 2000
100%
80%
60%
40%
20%
0%
Noordvaarder
Griend
Kroon's Polders
Hors
De Cocksdorp
Mokbaai
De Schorren
climax Riet
groen str / brak
climax Elymus
hoge zone
midden zone
lage zone
pionier zone

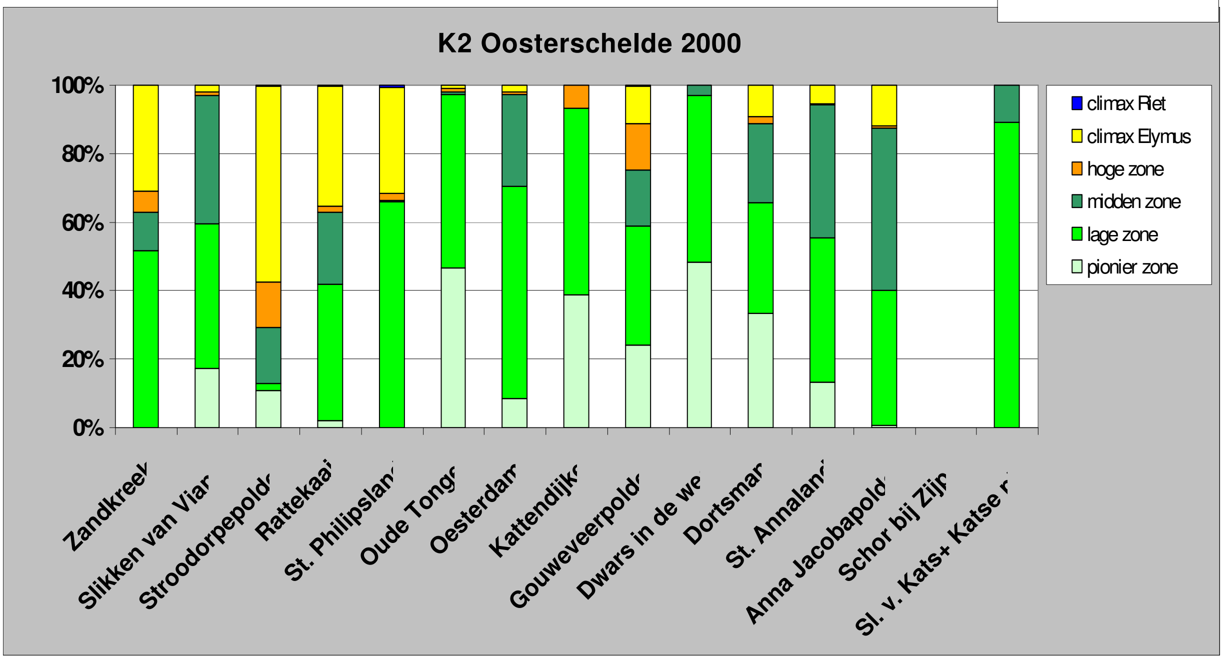

K2 Wadden Sea-NH main land 2000
100%
80%
60%
40%
20%
0%
Vatrop
Den Oever
Balgzand
climax
groen str /
climax
hoge
midden
lage
pionier

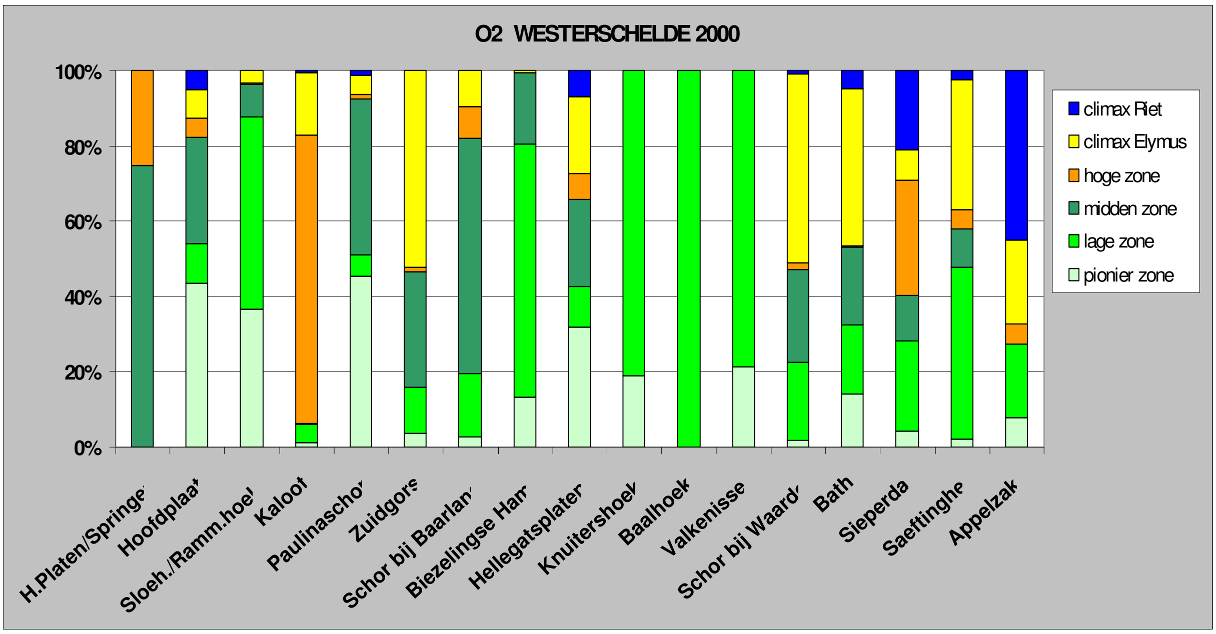

K3 Texel North Sea 2000
100%
80%
60%
40%
20%
0%
De Slufter
climax Riet
groen str / brak
climax Elymus
hoge zone
midden zone
lage zone
pionier zone


climax Reed
Green beach
/ brackish
climax Elymus
high zone
middle zone
low zone
pioneer zone *


K1 Haringvliet-mouth 2000
100%
80%
60%
40%
20%
0%
Slufter Voorne
Kwade Hoek
climax Riet
climax Elymus
hoge zone
midden zone
lage zone
pionier zone


K1 Westerschelde-mouth 2000
100%
80%
60%
40%
20%
0%
Zwin
Zwarte polder
climax Reed
Green beach / brackish
climax Elymus
high zone
middle zone
low zone
pioneer zone *


K2 Oosterschelde 2000
100%
80%
60%
40%
20%
0%
Zandkreek
Slikken van Viane
Stroodorpepolder
Rattekaai
St. Philipsland
Oude Tonge
Oesterdam
Kattendijke
Gouweveerpolder
Dwars in de weg
Dortsman
St. Annaland
Anna Jacobapolder
Schor bij Zijpe
Sl. v. Kats+ Katse h.
climax Riet
climax Elymus
hoge zone
midden zone
lage zone
pionier zone


O2 WESTERSCHELDE 2000
100%
80%
60%
40%
20%
0%
H.Platen/Springer
Hoofdplaat
Sloeh./Ramm.hoek
Kaloot
Paulinaschor
Zuidgors
Schor bij Baarland
Biezelingse Ham
Hellegatsplaten
Knuitershoek
Baalhoek
Valkenisse
Schor bij Waarde
Bath
Sieperda
Saeftinghe
Appelzak
climax Riet
climax Elymus
hoge zone
midden zone
lage zone
pionier zone

Appendix 4. Overview of valuation of salt marshes per (sub-)water body per year of monitoring

Year of monitoring 2000

ACREAGE IN HA	pioneer	low	middle high	high	brackish	Elymus	Reed	total
O2 Ems-Dollard	79	278	14	48	153	81	88	741
K2 Wadden Sea-GR-salt marsh *	507	537	112	50	10	205		1,420
K2 Wadden Sea-FR-salt marsh *	674	737	143	172	12	182	2	1,922
K2 Wadden Sea-NH-salt marsh	33	9	5	0,4	2	14	8	71
K2 Wadden Sea-E-islands	294	576	732	674	61	501	18	2,856
K2 Wadden Sea-W-islands	46	72	31	89	20	19	24	301
K3 Texel-North Sea	20	44	148	8	17	21	0,1	257
K1 Haringvliet-mouth	10	23	21	110		47	20	230
K2 Oosterschelde	53	201	166	8		79	0,4	508
K1 Westerschelde-mouth	3	6	21	9		17	0,1	57
O2 Westerschelde	90	998	291	146		790	81	2.395
TOTAL in ha	1,808.9	3,479.5	1,684.4	1,313.1	274.7	1,956.2	240.2	10,756.9

*: salt marsh zone <5% not included

ACREAGE IN %	pioneer	low	middle high	high	brackish	Elymus	Reed	total
O2 Ems-Dollard	10.7	37.5	1.9	6.5	20.6	10.9	11.8	100.0
K2 Wadden Sea-GR-salt marsh *	35.7	37.8	7.9	3.5	0.7	14.4	0.0	100.0
K2 Wadden Sea-FR-salt marsh *	35.1	38.3	7.4	9.0	0.6	9.5	0.1	100.0
K2 Wadden Sea-NH-salt marsh	46.9	12.1	7.2	0.6	3.5	19.0	10.7	100.0
K2 Wadden Sea-E-islands	10.3	20.2	25.6	23.6	2.1	17.5	0.6	100.0
K2 Wadden Sea-W-islands	15.2	24.0	10.3	29.5	6.7	6.4	7.9	100.0
K3 Texel-North Sea	7.7	17.0	57.5	3.0	6.5	8.3	0.0	100.0
K1 Haringvliet-mouth	4.1	9.9	9.1	47.7		20.4	8.7	100.0
K2 Oosterschelde	10.5	39.5	32.8	1.5		15.6	0.1	100.0
K1 Westerschelde-mouth	5.2	10.9	37.3	16.4		30.0	0.1	100.0
O2 Westerschelde	3.8	41.7	12.1	6.1		33.0	3.4	100.0
TOTAL in %	16.8	32.3	15.7	12.2	2.6	18.2	2.2	100.0

*: salt marsh zone <5% not included

SCORE TABLE	pioneer	low	middle high	high + Elymus	brackish +Reed	Elymus > high	Reed > brackish	score	classes	quality#
O2 Ems-Dollard	1	0	0	1	1	0	1	4	7	P-GES
K2 Wadden Sea-GR-salt marsh *	1	1	1	1		0		4	5	P-GES
K2 Wadden Sea-FR-salt marsh *	1	1	1	1		0		4	5	P-GES
K2 Wadden Sea-NH-salt marsh	0	1	1	1		0		3	5	P-GES
K2 Wadden Sea-E-islands	1	1	1	0	0	1		4	6	P-GES
K2 Wadden Sea-W-islands	1	1	1	0	1	1		5	6	P-GES
K3 Texel-North Sea	1	1	0	1	1	0		4	6	P-GES
K1 Haringvliet-mouth	0	1	1	0		1		3	5	P-GES
K2 Oosterschelde	1	1	1	1		0		4	5	P-GES
K1 Westerschelde-mouth	1	1	1	0		0		3	5	P-GES
O2 Westerschelde	0	0	1	1		0		2	5	Moderate
TOTAL	1	1	1	1	0	0		4	6	P-GES

if zone <5% or >35% then 0 otherwise 1

If zone <5% or >40% then 0 otherwise 1

class not included in 'score' water system, as it occurs hardly or not at all in it

zone high = high + climax Elymus

zone brackish = brackish + climax Reed

#: for assessment see table in Chapter 3

Year of monitoring 1990

ACREAGE IN HA	pioneer	low	middle high	high	brackish	Elymus	Reed	total
O2 Ems-Dollard	0	385	34	35	164	76	61	755
K2 Wadden Sea-GR-salt marsh *	393	418	470	17		53	15	1,367
K2 Wadden Sea-FR-salt marsh *	329	883	86	203	44	139		1,684
K2 Wadden Sea-NH-salt marsh	17	10	1	1		5	1	35
K2 Wadden Sea-E-islands	217	482	1,025	260	90	390	25	2,489
K2 Wadden Sea-W-islands	38	51	26	37	15	10	11	188
K3 Texel-North Sea	42	52	147	11	13	30	0,3	294
K1 Haringvliet-mouth	107	13	36	186		42	15	399
K2 Oosterschelde	91	242	180	19		56	0,3	589
K1 Westerschelde-mouth	1	2	24	33		18	0,1	79
O2 Westerschelde	95	868	345	141		883	44	2,376
TOTAL in ha	1,329	3,404	2,374	945	326	1,702	174	10,254

*: salt marsh zone <5% not included

ACREAGE IN %	pioneer	low	middle high	high	brackish	Elymus	Reed	total
O2 Eems-Dollard	0.0	51.0	4.5	4.6	21,7	10.0	8,1	100.0
K2 Wadden Sea-GR-salt marsh *	28.8	30.6	34.4	1.3	0,0	3.9	1,1	100.0
K2 Wadden Sea-FR-salt marsh *	19.5	52.4	5.1	12.1	2,6	8.3	0,0	100.0
K2 Wadden Sea-NH-salt marsh	47.4	29.1	1.6	3.0	0,0	14.9	4,1	100.0
K2 Wadden Sea-E-islands	8.7	19.3	41.2	10.4	3,6	15.7	1,0	100.0
K2 Wadden Sea-W-islands	20.1	27.1	13.8	19.9	7,9	5.4	5,8	100.0
K3 Texel-North Sea	14.2	17.6	49.9	3.8	4,3	10.1	0,1	100.0
K1 Haringvliet-mouth	26.8	3.2	9.1	46.6	0,0	10.4	3,8	100.0
K2 Oosterschelde	15.4	41.1	30.6	3.3	0,0	9.6	0,1	100.0
K1 Westerschelde-mouth	1.9	2.0	30.7	42.1	0,0	23.2	0,2	100.0
O2 Westerschelde	4.0	36.5	14.5	5.9	0,0	37.2	1,9	100.0
TOTAL in %	13.0	33.2	23.2	9.2	3,2	16.6	1,7	100.0

*: salt marsh zone <5% not included

SCORE TABLE	pioneer	low	middle high	high + Elymus	brackish + Reed	Elymus > high	Reed >brackish	score	classes	quality#
O2 Ems-Dollard	0	0	0	1	1	0	1	3	7	moderate
K2 Wadden Sea-GR-salt marsh *	1	1	1	1		0		4	5	P-GES
K2 Wadden Sea-FR-salt marsh *	1	0	1	1		1		4	5	P-GES
K2 Wadden Sea-NH-salt marsh	0	1	0	1		0		2	5	Moderate
K2 Wadden Sea-E-islands	1	1	0	1	0	0		3	6	moderate
K2 Wadden Sea-W-islands	1	1	1	1	1	1		6	6	P-REF
K3 Texel-North Sea	1	1	0	1	0	0		3	6	moderate
K1 Haringvliet-mouth	1	0	1	0		1		3	5	P-GES
K2 Oosterschelde	1	0	1	1		0		3	5	P-GES
K1 Westerschelde-mouth	0	0	1	0		1		2	5	Moderate
O2 Westerschelde	0	1	1	0		0		2	5	Moderate
TOTAL	1	1	1	1	0	0		4	6	P-GES

If zone <5% or >35% then 0 otherwise 1

if zone <5% or >40% then 0 otherwise 1

class not included in 'score' water system, as it occurs hardly or not at all in it

zone high = high + climax Elymus

zone brackish = brackish + climax Reed

#: for assessment see table in Chapter 3

Year of monitoring 1980

ACREAGE IN HA	pioneer	low	middle high	high	brackish	Elymus	Reed	total
O2 Ems-Dollard		430	21	30	194	57	64	796
K2 Wadden Sea-GR-salt marsh *	836	623	215	10		35		1,720
K2 Wadden Sea-FR-salt marsh *	522	708	387				0,2	1,617
K2 Wadden Sea-NH-salt marsh	15	7	5	4		3	0,1	34
K2 Wadden Sea-E-islands	211	514	936	372	66	268	41	2,408
K2 Wadden Sea-W-islands	39	40	56	11	1	3	38	190
K3 Texel-North Sea	31	51	163	9	12	21		286
K1 Haringvliet-mouth	18	3	3	15			0.3	38
K2 Oosterschelde	252	282	260	4		3		801
K1 Westerschelde-mouth	16	0.2	54	34		35	0.2	139
O2 Westerschelde	332	688	468	355		510	27	2,381
TOTAL in ha	2,271	3,347	2,567	845	273	935	171	10,409

*: salt marsh zone <5% not included

ACREAGE IN %	pioneer	low	middle high	high	brackish	Elymus	Reed	total
O2 Ems-Dollard	0.0	54.0	2.6	3.8	24,4	7.1	8,1	100.0
K2 Wadden Sea-GR-salt marsh *	48.6	36.3	12.5	0.6	0,0	2.0	0,0	100.0
K2 Wadden Sea-FR-salt marsh *	32.3	43.8	23.9	0.0	0,0	0.0	0,0	100.0
K2 Wadden Sea-NH-salt marsh	43.5	20.9	15.1	10.4	0,0	9.7	0,4	100.0
K2 Wadden Sea -E-islands	8.8	21.4	38.9	15.4	2,7	11.1	1,7	100.0
K2 Wadden Sea-W-islands	20.6	21.3	29.6	6.0	0,6	1.6	20,1	100.0
K3 Texel-North Sea	10.8	17.7	56.9	3.3	4,0	7.3	0,0	100.0
K1 Haringvliet-mouth	45.7	7.0	6.9	39.6	0.0	0.0	0.7	100.0
K2 Oosterschelde	31.5	35.3	32.4	0.5	0.0	0.3	0.0	100.0
K1 Westerschelde-mouth	11.1	0.2	38.7	24.8	0.0	25.1	0.1	100.0
O2 Westerschelde	13.9	28.9	19.7	14.9	0.0	21.4	1.1	100.0
TOTAL in %	21.8	32.2	24.7	8.1	2.6	9.0	1.6	100.0

*: salt marsh zone <5% not included

SCORE TABLE	pioneer	low	middle high	high + Elymus	brackish + Reed	Elymus > high	Reed > brackish	score	classes	quality#
O2 Ems-Dollard	0	0	0	1	1	0	1	3	7	moderate
K2 Wadden Sea-GR-salt marsh *	0	1	1	0		0		2	5	Moderate
K2 Wadden Sea-FR-salt marsh *	1	0	1	0		1		3	5	P-GES
K2 Wadden Sea-NH-salt marsh	0	1	1	1		1		4	5	P-GES
K2 Wadden Sea-E-islands	1	1	0	1	0	1		4	6	moderate
K2 Wadden Sea-W-islands	1	1	1	1	1	1		6	6	P-REF
K3 Texel-North Sea	1	1	0	1	0	0		3	6	Moderate
K1 Haringvliet-mouth	0	1	1	1		1		4	5	P-GES
K2 Oosterschelde	1	1	1	0		1		4	5	P-GES
K1 Westerschelde-mouth	1	0	1	0		0		2	5	Moderate
O2 Westerschelde	1	1	1	1		0		4	5	P-GES
TOTAL	1	1	1	1	0	0		4	6	P-GES

if zone <5% or >35% then 0 otherwise 1

if zone <5% or >40% then 0 otherwise 1

[grey box] class not included in 'score' water system, as it occurs hardly or not at all in it

zone high = high + climax Elymus

zone brackish = brackish + climax Reed

#: for assessment see table in Chapter 3

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