Summary

Development of island tails
Geomorphology, water cycle and vegetation

Introduction

This report examines the eastern parts of the Wadden Islands that are open to the sea, the so-called island tails. When fully developed, they consist of beach plains, beaches, salt marshes, green beaches, dunes, washovers and washover complexes.

Partly due to human interference, the natural dynamics of the island tails have diminished and succession has led to *ageing*, with negative consequences for the biodiversity. There is however a trend towards management measures that (re)introduce natural processes as a means to stimulating rejuvenation. Their effectiveness cannot be assessed, however, as basic knowledge of island tail development is still lacking.

This report discusses the geomorphology, water cycle and vegetation of islands tails. These include island tails in the Lower Saxony region of Germany in order to learn from other management visions. This provides an impression of how island tails develop in the course of time, which can serve as a guideline for managers in substantiating their management measures.

The function that island tails fulfil in water safety is also important. Nature management measures were viewed in light of water safety (Delta Program Wadden Sea area). Fortunately, virtually every case showed that none of the human interferences, not even large-scale interferences in the island tails, will have any negative effects on the safety of both the island population as well as the coast of the mainland. The Dutch program Towards a Rich Wadden Sea also contributed to the realization of this report: they support initiatives that aspire to develop a healthy and resilient Wadden Sea.

An important recommendation in this report is that each management measure regarding the island tails must be made-to-measure and embedded in an adequate understanding of the general development of island tails and the unique development of the specific island tail concerned.

Under ideal circumstances, the Wadden islands consist of a number of characteristic elements. The ‘model island’ below is based on Spiekeroog, which by comparison still demonstrates the greatest degree of natural development and the historical situations on other Wadden islands.

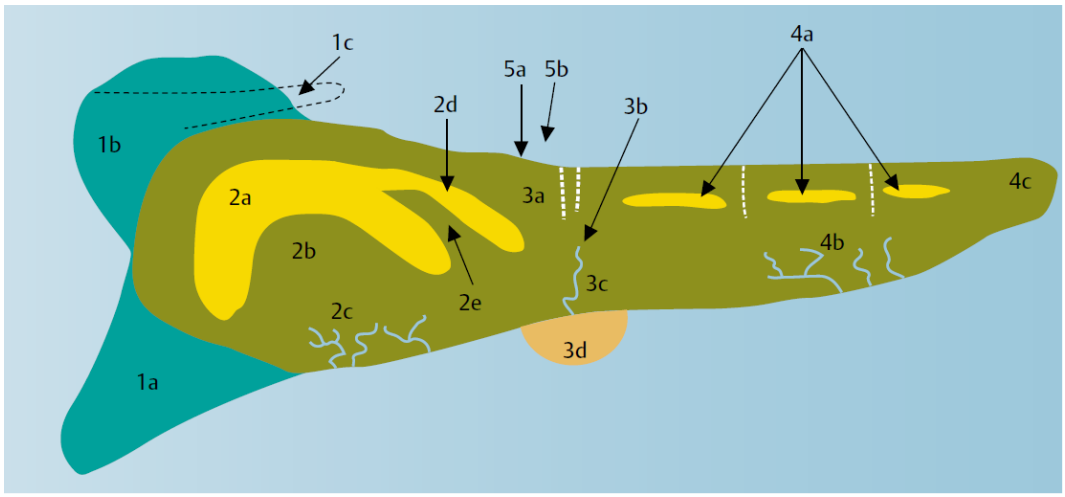

***Figure 1**. Model island and its elements: 1 = island head, 2 = dune arc complex, 3 = washover complex, 4 = island tail, 5 = beach and foreshore. Dominant transport direction is from left to right (Löffler et al., 2008).*

An island tail is the part of a Wadden island that is open to the sea and located on the 'downstream' side of the island in relation to the net direction of transport (the result of transport generated through wave-driven current and tide; Fitzgerald et al., 1984). The island must have at least one well-developed dune arc complex (a curved row of dunes behind which a salt marsh has developed) on the upstream side where the island head is located as well. The net tidal current is eastward along the Wadden coast of the Netherlands and Nedersaksen. The island tails are therefore located on the eastern side of the complete dune arc complex located farthest to the east. The shape of island tails is not stable, but rather changes with time. The elements washover complex, beach and foreshore are also often considered to make up (part of) the island tail.

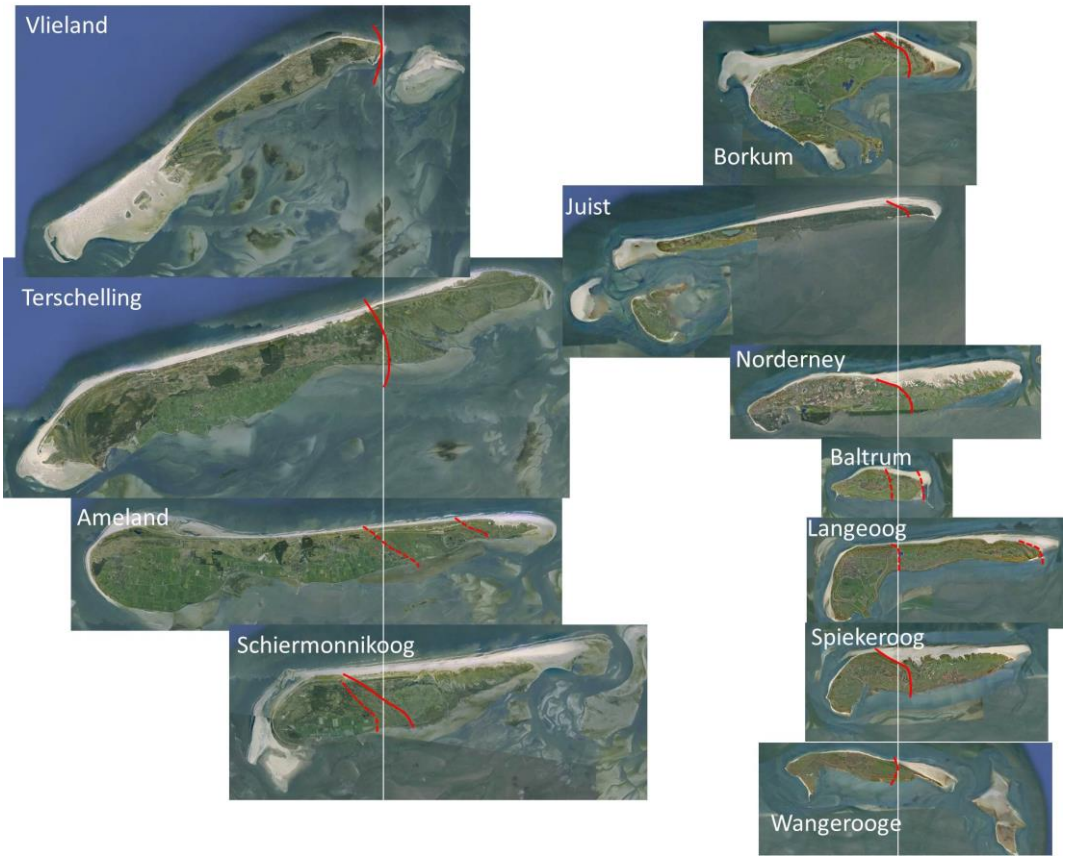

***Figure 2**. Overview of the island tails of the Netherlands (left) and Lower Saxony (right). The scale of the figures is the same. Tidal range increases from upper left to lower right. Red lines indicate the western border of the island tail (solid line = certain, dotted line = uncertain), and the islands have been shifted such that the beginning of the island tail lies around the white line.*

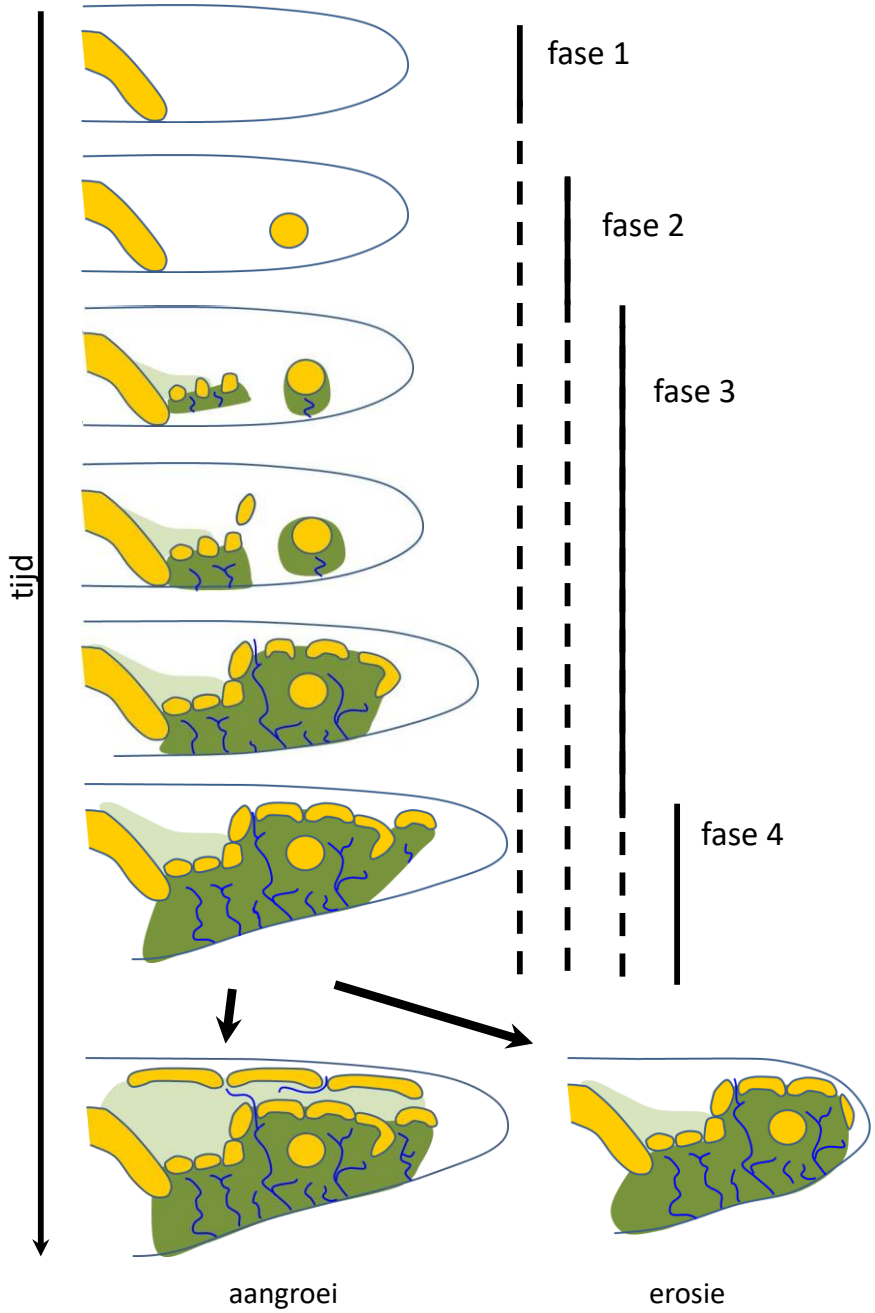

***Figure 3**. Conceptual model of island-tail development (partly after Ten Haaf & Buijs, 2008). In these figures the North Sea is towards the top of the figures and the Wadden Sea towards the lower side. Yellow = dunes, dark green = salt marsh, light green = green beach, blue = creeks. The phases overlap as one part of the tail can be in one phase, while some other part is still in a previous phase. Fase = phase / tijd = time / aangroei = accretion / erosie = erosion*

Island tail development – Reference model and human interferences

The development of the geomorphology, water cycle and vegetation on island tails comprises a clear succession of phases (Table 1 below). Island tails are generated through the dynamics of natural processes. These processes also create a zoning consisting of various landscape elements, such as beach, beach plain, salt marsh, dune and green dune. These elements are not static, but develop in the course of time. They may also increase or decrease in size. And so the "model island" is too static as a representation.

The degree to which an island tail and its elements are developed depends upon the age and the size of the island tail (accommodation space), as well as the extent and timing of human influences, as these influence natural processes. And so each island has its own unique development. Of the islands studied in more detail, Spiekeroog has the least degree of succession, followed by Schiermonnikoog and Terschelling is farthest along. This has direct consequences for the room that is available for the further development of the individual elements and the flora and fauna related to these elements.

There is not only room for growth and succession under natural circumstances, but also for erosion and regression. Tempo and direction are then determined by the natural large-scale developments (Holocene development, development within estuary systems, island shifts, et cetera) and by developments on a smaller scale (elements of the island mutually influence one another, interaction abiotic-biotic, et cetera). If the influence of biotica becomes dominant and is not corrected by large-scale processes, then these may strongly determine the groundwater bodies, tidal creeks and washovers. And with that, biotica can influence the effects of seawater flooding in the area and in turn, the further morpho-ecological development.

***Table 1**. Summary of the factors, processes, changes in shape and habitat types in the four phases of island-tail development.*

Phase 1	**Phase 2**	**Phase 3**	**Phase 4**
Factors that determine what happens and when			
Accommodation space Energy gradients	Height => inundation decreases => vegetation takes hold.	Dunes large enough and so lee comes about Efflux freshwater groundwater	Vegetation cover closes Expansion of elements resulting in more lee
Dominant processes in this stage			
Transport of sediment by waves and current Transport of sand by the wind	Transport of sediment by waves and current Growth beach/beach plain Storms: erosion + overwash) Transport and deposit of sand by the wind Structuring of groundwater lenses Vegetation takes hold (facilitation)	Deposit of sludge (salt marsh) Transport and deposit of sediment by waves and current Transport and deposit of sand by the wind Storms: erosion + overwash Vegetation takes hold (facilitation) Vegetation succession (competition) Formation of drainage Nitrogen fixation, stacking of organic matter, more nutrients through	Vegetation succession (competition dominant) Soil formation, further staking of organic matter, decalcification Cliff erosion Sludge deposit (salt marsh) Transport and deposit of sediment by waves and current Transport and deposit of sand by the wind Storms: erosion + overwash Herbivores/change food web

		silting Soil formation Redox conditions change Herbivores/change food web	
Changes in shape			
Shallow build-up Small running dunes	Changes in shape: (Fields of) Embryo dunes	Washover complexes are formed, salt marshes and salt marsh creeks develop Dunes build up further, structuring groundwater lenses	Sand accumulation washovers, dune arch formation Expansion and/or silting up of creeks New dune formation Primary dune valleys Salt marsh cliff
Occurring Habitat type [a)]			
H1140	H1140, H2110, H2120, H1310	H1140, H1310, H1320, H1330, H2110, H2120, H2130	H1140, H1310, H1320, H1330, H2110, H2120, H2130, H2140, H2150, H2160, H2170, H2190,

[a)] H1140 (mudflats and sandbar that fall dry at low tide); H1310 (salty pioneer vegetation); H1320 (spartina grass plains); H1330 (salt marshes and salty grasslands); H2110 (Embryonal dunes); H2120 (white dunes); H2130 (grey dunes); H2140 (heathlands with crowberry); H2150 (heathlands with heather); H2160 (sea buckthorn shrubs); H2170 (creeping willow shrubs); H2190 (Moist dune valleys)

***Figure 4**. Island tail of Spiekeroog, viewed towards the east from the most eastward dunes (2013, photo Alma de Groot).*

***Figure 5**. Embryo dunes on Spiekeroog (Foto Alma de Groot, 2013).*

Speed of ageing

The geo-morphological development is slower on islands that are not influenced by human interference compared to islands with a drift-sand dyke. The development of vegetation on the salt marsh also appears to proceed more slowly, compare Spiekeroog to Schiermonnikoog. The reason is that the abiotic processes from the North Sea can penetrate deeper in the island tail, and so the area as a whole does not develop all at once and the succession is maintained in an earlier stage locally.

The speed of development also differs from one island tail to the other. Salt marshes on island tails progress through a number of succession stages and are completely matured after about a century. Within the course of decades, dunes can develop from embryo dunes to white dunes to grey dunes. Green beaches that are sufficiently protected can develop even quicker, as the current situation on Schiermonnikoog and Spiekeroog shows. Their development then proceeds in the direction of a mosaic of dunes, salt marsh and/or dune valleys, so that their original appearance and location on the beach is often temporary (not more than a few decades). Regarding washover complexes however, it seems that the combination of microbial mats, erosion caused by overwash and Aeolian deposits can lead to the preservation of the status quo for centuries even (Meyer-Deepen & Meijering, 1979; Oost, 1995; Ten Haaf & Buijs, 2008). However, no specific research has been conducted in this respect.

Another cause of the accelerated succession of vegetation is the increased nitrogen deposits: island marshes and dunes are nitrogen-limited systems. Despite this, there is still a correlation between the clay thickness and the succession stage of the salt marsh on Schiermonnikoog.

Convergence

The construction of a sand-drift dike actually implies the forced development of a dune arch, in which the natural spine of the young low dunes in the middle of the island tail does not have time to develop and washover complexes are closed off. The presence or absence of a spine of this can could be a decisive factor regarding the development of the pattern of creeks. (For example, compare Spiekerogg and the eastern tip of Ameland with a spine and more short 'hairy' creeks on the one hand, to Schiermonnikoog en Terschelling with branched creeks across a low flat on the other. However, in view of the major differences that can sometimes be observed between the creeks per island, other factors also play a role.

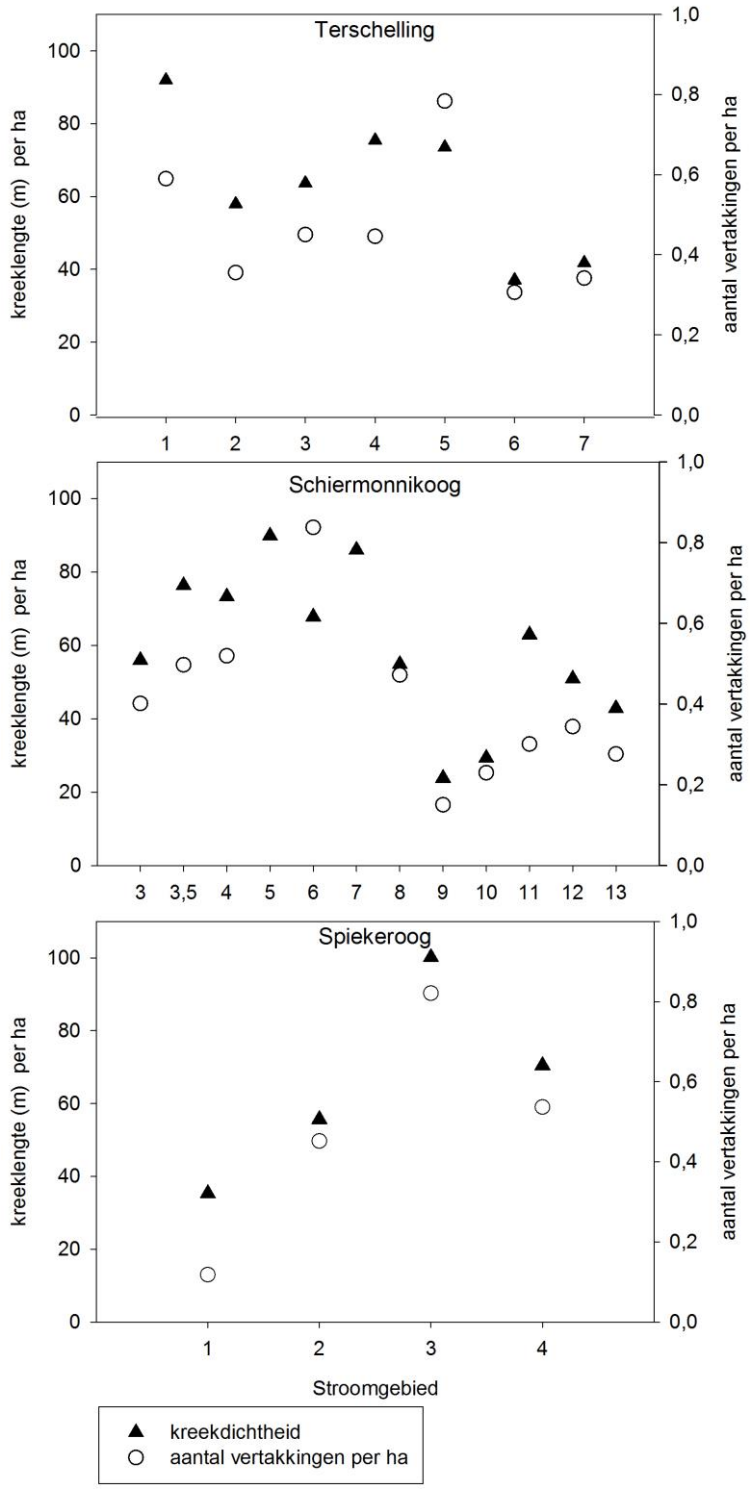

***Figure 6**. Creek density (creek length per ha) and the number of branches for the three island tails. The areas are numbered from west to east.*

The sand-drift dikes have accelerated the development where it concerns the areas behind the dune arch (particularly salt marshes) and have also fundamentally changed it. For example, there would have been a washover complex between the dune arch and the island tail for a prolonged period and there would have been multiple washovers further down the island tail as part of a rippled foredune. A natural dune arch must close before it even resembles a situation with a sand-drift dike, but then accompanied by far more spatial variation in the whole area.

Future developments

Autonomous developments

It is evident from the current development of the island tails that the succession of the vegetation will continue. However, there will be small-scale internal processes (wetting, damming up of creeks, grazing, erosion of salt marsh borders, excess drift-sand, dune erosion during storms) that may be able to push back the succession of the vegetation. Large-scale counteracting of the vegetation succession can only be realized through processes that occur on a longer time scale and larger spatial scale than the developments within an island tail.

***Figure 7**. Eastern tip of Schiermonnikoog in 2011, with the highest part (berm) on the North Sea side with mobile dune formation (white). Towards the Wadden Sea, white dunes are migrating over a grey wet area. Fewer dunes are present in the lee of the vegetated dune ridge (right). (photo RWS Beeldbank).*

Climate change and consequences for the island tails

The expected developments for the climate in the Netherlands in the 21st century have been laid down in the KNMI'14 climate scenario's (Klein Tank et al., 2014, http://www.klimaatscenarios.nl/). The expected changes regarding the wind climate are minor, for the extremes as well. The temperature will continue to increase and there will be more mild winters and hot summers. The average precipitation and the extreme precipitation in the winter will increase. The intensity of the extreme rain showers in the summer will increase as well, hail and thunderstorms will become more violent. On the other hand, because of the increased evaporation, draught has occurred slightly more often since 1951. The sea level rise will accelerate in the course of the 21st century, but there is still a lot of uncertainty regarding these prognoses. The rise in the sea level is expected to be between 1 – 7.5 mm/year in 2050 and 1 – 10.5 mm/year in 2085 (Dillingh et al., 2010; Katsman et al., 2011; Klein Tank et al., 2014).

The growth season will be prolonged further to a temperature increase and the increase in precipitation may possibly enhance the development of vegetation. However, increasing draught in the summer and increasing summer temperatures may cause stress situations for plants. The vegetation cover may therefore increase or decrease and the composition may change. This will partly depend upon the groundwater level. The density of the plant cover is important in fixing the

dune and therefore the degree of sand drifting and rejuvenation. It is still not clear which developments can be expected (for example, Keijsers et al., 2014).

An acceleration of the rise of the sea water level and a possible increase of storm tides will increase the frequency of overwash and flooding if this is not counteracted by a greater import of sediment and its accelerated accumulation. As it is, the sediment can be transported more frequently all the way to the island tail during overwash and regular flooding. In the area that is directly influenced by an overwash and on the salt marsh, this will contribute to developing along with the rise in the sea level. No sand will be deposited from the North Sea at locations where drift-sand dykes have closed off the former washovers and washover complexes. To which extent this is compensated by the supply of sludge from the Wadden Sea side is not known. The soil subsidence study Ameland (Dijkema et al., 2011), among other studies, shows that the speed of sedimentation decreases in relation to the distance to the wad and the salt marsh creeks, as a result of which only a limited amount of sludge reaches the areas far from the wad. And so the surface level may fall behind in relation to the relative sea level increase, possibly leading to a higher inundation frequency and inundation time. When and whether or not this has an effect on the vegetation (regression or continued succession) depends upon the speed of the sea level increase and the location of the salt marsh. However, the salt marsh vegetation that has taken root is found to be much more robust subject to sea level increases than previously supposed (Dijkema et al., 2011). Whether or not the expected decrease of extreme frost and floating ice will have a major effect on the island tails is not yet known.

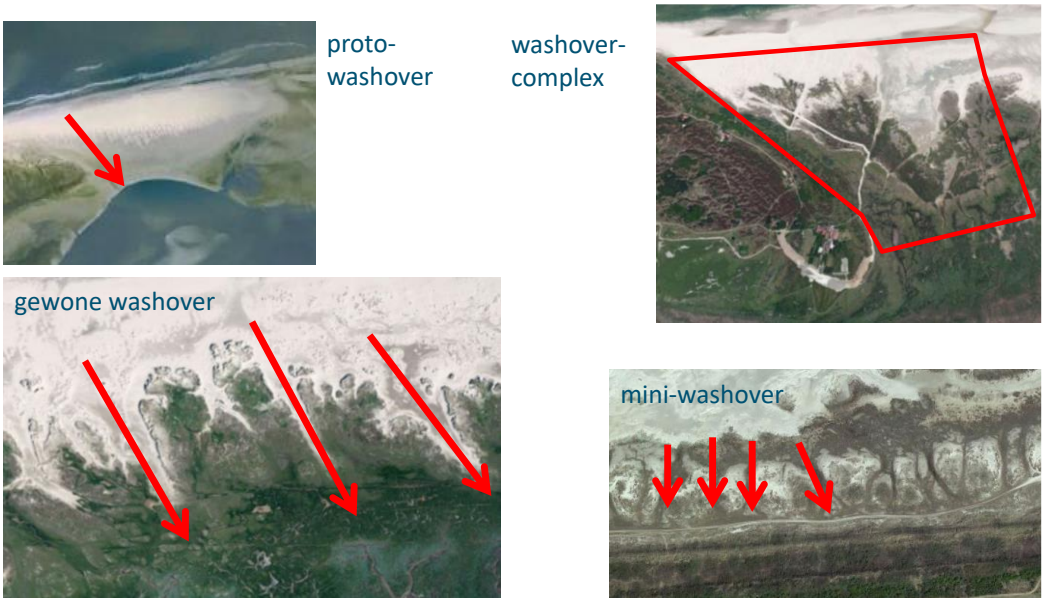

***Figure 8**. Different forms of washover: proto-washover, washover complex, normal washover and mini-washover.*

Water safety

The function of the island tails in water safety has been described by Oost & Van Rooij (2012): "The whole of the North Sea coastal zone, the islands and the Wadden Sea protects the mainland against flooding, as they cushion the storm waves that roll in from the North Sea. In addition, there is the matter of safety on the islands themselves. This was most likely an issue from the very start that people occupied the islands. Efforts to that end particularly increased in the 19th and 20th century, involving changes from local restoration management to large-scale preventive management in which *Rijkswaterstaat* and *Staatsbosbeheer* (Department of Waterways and Public Works and the Forestry Commission) played an important role."

It is not a matter-of-course that the Wadden islands will always continue to exist without the implementation of protective measures. At present, sand supplements regularly take place on Ameland. Climate change and developments already underway (such as soil subsidence due to the extraction of natural gas and the effects of the IJsselmeer Dam) will likely render large-scale

management and maintenance efforts necessary, which are expected to mainly involve sand supplements. This may involve supplementing on a more regular basis or using larger amounts. Both options may possibly interfere with the development of the island tails. Integrating coastal and nature management in both space and time will then become even more important.

Management – Nature policy

The starting point of the current nature policy (Natura 2000, PKB Waddenzee, Framework directive Water and Trilateral agreements) is that priority is to be given to allowing natural processes to proceed on the island tails without interference, which should benefit the most vulnerable habitats in the long term. The Natura 2000 management plans also take into consideration that major natural fluctuations in the occurrence of species and habitats may take place in such dynamic regions both in space and time.

Significant human interferences that may possibly influence the Natura 2000 regions are shown in the "effects indicator" (http://www.synbiosys.alterra.nl/natura2000/effectenindicator.aspx?subj=effectenmatrix). This is an instrument that can be used to explore the potentially harmful effects further to human activities and plans. The effects indicator provides information regarding the sensitivity of species and habitat types for the most frequently occurring interfering factors. This information is generic: further research is required in order to determine whether or not an activity is harmful in practice.

Planning measures and management measures

There are a number of measures that offer possibilities to undo the bio-geomorphological succession (sometimes locally), possibly increasing the total biodiversity.

(Partially) removing **drift-sand dykes** to allow for/reintroduce overwash processes. This will boost the water dynamics and result in a greater chance of aeolian sand transport from the beach in the direction of the region that lies behind the beach. The measure may comprise one or more notches, a large hole or removing the drift-sand dyke in its entirety. Points of special interest are:

- the presence of marram grass roots (can sprout quickly and stabilize the sand),
- what to do with the sand that is dug up,
- possible presence of a green beach on the seaward side (limits wind and water dynamics),
- the drainage (creeks) present in the salt-marsh,
- the condition of the soil in the area towards the land (nutrients, organic matter, clay),
- possible influence on the local water safety.

Allowing or stimulating **sand-drifts** in dunes results in the introduction of increased water dynamics where dunes disappear and an increased transport of sand towards the land (new dunes develop). This can be achieved by removing the vegetation. Another option is to simply do nothing (dynamic coastal management), which in practice means waiting for large-scale changes in the area. Points of special interest are:

- the presence of marram grass roots (can sprout quickly and stabilize),
- it is evident from attempts in the past to increase dynamics that this must be realized across a sufficiently large area with due regard for the specific terrain situation.

Allowing the **erosion** of the edges of the salt marsh to take place from the Wadden Sea. This comprises the removal of layers of rocks and other protective measures. This may lead to the formation of cliffs in the short term. The formation of new salt marshes in the eroded area, and with that rejuvenation, may occur in the eroded area in the long term. Although there is little practical experience with this method (known from estuaries) on the Wadden islands, there are no reasons to assume that this process would proceed any differently in the Wadden Sea region.

Vegetation management of dunes and/or salt marshes comprises a broad range of possibilities, varying from aboveground measures (mowing and pasturing) to soil-disturbing measures (superficial cutting of sods or digging off a deeper layer). This will rejuvenate the vegetation or even reduce the development back to the pioneer phase. These processes also remove nutrients and sand dynamics are once again possible in the dunes. Points of special attention in this respect: cattle safety, trampling, removal of mowed grass, cutting of sods and removal of soil, digging off a salt marsh will require a connection to creeks to enable the supply and removal of water and

sediment. Suitable locations (end stages of the succession series) are present on virtually all of the island tails. Customized measures are important in this respect as well.

Management by means of **supplements** may involve supplementing specific locations or (temporarily) refraining from regular supplements. Extra supplements, either on the island tail or in its vicinity, result in an extra supply of sand and therefore extra space for the formation of dunes and green beaches. If the supplements are omitted, then erosion may occur, allowing for large-scale deterioration followed by the rejuvenation of the vegetation or perhaps a total restart of landscape elements. Points of interest are whether supplements fit into the large-scale changes and the fact that an extra supply of sand may cause the foredune to rigidify when embryonic dunes develop. Supplements may also influence parts of the islands other than the tail because the net transport of sand is eastward.

***Table 2**. TMAP vegetation types (based on TMAP Monitoring Handbook 2009), condensed into 7 main types. Other consists of surface area lacking vegetation (water or soil) and pre-pioneer zone (<5% Salicornia).*

	abbreviation	vegetation type
other		
D	D	Dune vegetation, unspecified
Da	Da	*Ammophila arenaria* type
B*	B*	Brackish salt marsh, unspecified
Gf	Gf	Green beach, *Elymus farctus* type
H*	H*	High salt marsh, unspecified
Hf	Hf	*Festuca rubra* type
Hg	Hg	*Agrostis stolonifera / Trifolium fragiferum* type
Hj	Hj	*Juncus gerardi / Glaux maritima* type
Hl	Hl	*Limonium vulgare / Juncus gerardi* type
Hx	Hx	*Atriplex prostrata / Atriplex littoralis* type
Hy	Hy	*Elytrigia atherica* type
Hz	Hz	*Artemisia maritima / Festuca rubra* type
La	La	*Aster tripolium / Puccinellia maritima* type
Lh	Lh	*Atriplex portulacoides / Puccinellia maritima* type
Ll	Ll	*Limonium vulgare / Puccinellia maritima* type
Lp	Lp	*Puccinellia maritima* type
P*	P*	Pioneer zone, unspecified
Pq	Pq	*Salicornia spp. / Suaeda maritima* type
Ps	Ps	*Spartina anglica* type

Management and organization recommendations

Based on the above, the following management and policy recommendations can be put forward for island tails:

1. The variation between the island tails make it difficult to come up with a general 'recipe'. Management measures must therefore be made-to-measure and must anticipate on the specific situation per region and per island.

2. Island tail management is integrated management:
    a. Keep in mind the various time scales and spatial scales and anticipate upon these.
    b. When making choices, keep in mind the mutual dependency of the elements. One element may hinder the transport of sediment to another element, for example, or may generate lee as a result of which some other element develops differently. The presence of a green beach, for example, will mean a low supply of sand to the foredune.
    c. Dynamics also comprise the (temporary) disappearance of certain habitat types.

3. It is important to realize that bio-geomorphological succession is a natural process for island tails. The presence of all of the stages of succession goes hand in hand with the greatest biodiversity, as various species and habitat types achieve their optimal state in various stages of succession.

4. Rejuvenation (locally) may be an option when young stages of succession are oppressed as a whole across the Wadden islands. If measures to promote rejuvenation are being considered, then it is important to have clarity in advance regarding the following:
    a. the extent to which rejuvenation is genuinely necessary in the specific area (in relation to local, regional, national, Wadden Sea or international interest);
    b. what the precise management goals are in that case;
    c. which management measure or which interference is most suitable in the short or long term. Once-only human measures, after which the natural processes take over, have preference over repeated human measures;
    d. whether or not, in view of the developmental phase of the island tail, it is still feasible to move the situation back in its succession. This requires a made-to-measure approach to the individual island tails, and even to sections of each island tail.

5. Expectations are that reintroducing dynamics in sections of the island tail on a large-scale can be realized by means of sand drifting or washover restoration.

6. Concerning the local rejuvenation of vegetation, limited, goal-oriented management by means of grazing and cutting sods may be an option. However, the geomorphology is not, or to a lesser degree, rejuvenated as a result.

7. The various stages have a varying sensitivity to human interference, depending upon the substrate, the dynamics and the characteristics of the vegetation. Pioneer vegetation on salt marshes and green beaches in particular are extremely sensitive to disruption (creek formation, destruction of vegetation).

8. Strong dynamics in space and time (that is to say, rapid changes and strong abiotic dynamics) are essential to green beaches, beaches, washover complexes, washovers and beach plains. The location of habitat types within the space should therefore not be dictated by policy.

9. With respect to major interventions, make sure that the supply and discharge routes of the water are as logical/most natural as possible. This increases the predictability of the effects of the interference.

10. Ensure spatial variation, that is to say, avoid taking the same management measures on each island and for each part of an island. That is the most robust situation when subject to external changes and will yield the highest biodiversity.

11. Plans to restore dynamics on a large-scale should take into account possible consequences for the dams in the vicinity. Consequences may be negative (greater hydraulic loads, smaller dune), but also positive (raising of foreland, dune more robust).

12. Until now, nature management on the island tails has mainly focused on sections of the salt marshes or dunes. There has been little attention for the green beaches, beaches, beach plains, washovers and washover complexes and the mutual relationships between these elements. Having due regard for the entire island tail, it is possible to optimize the management and to make it more sustainable.

Conclusions

Human interference in the past
Human interventions have/have had major effects on the development of island tails. This mainly concerns the construction of drift-sand dykes. The former geomorphology is largely fossilized by the drift-sand dyke and some elements have not developed altogether, such as washovers and washover complexes. The salt marshes saw an accelerated development and cover large areas. The succession of the vegetation has accelerated across the entire tail. As spatial variation is lacking, there are fewer fresh-salt gradients. Together, this has led to a situation in which the biotic and abiotic variation has decreased in space and time and the island tails have aged quickly.

Present situation
The present situation differs per island tail, depending upon when and where the drift-sand dyke was constructed, in which stage the island was at that time and how the large-scale processes have since influenced the island tail. Some locations show a delay in succession as a result of the grazing of salt marsh and dunes and digging off dune valleys. There is also some local regression due to excess water and erosion. Of the Dutch islands, the succession has proceeded the farthest on Terschelling, the tail of which is in an erosion phase. The western part of the tail of Ameland (Neerlands Reid) has been almost entirely fixed, while the eastern section (De Hon) is influenced much more by natural processes. Schiermonnikoog shows a clear gradient from an older, more fixed area on the west side to a young, eastern point that is still developing.

The dominant factors that steer the development of the vegetation on the salt marshes are: natural succession (time), human interventions (mainly drift-sand dykes), expansion of the salt marsh on the south side, thickness of the clay layer and with that, nutrients, and the development of a green beach or washover complex.

Management measures and organization measures
The island tails already rank among the most dynamic parts of the Dutch coast. If any place offers opportunities in management to just let the natural processes do their thing, then this is the place.

A drift-sand dyke is actually a man-made 'dune arch'. If no drift-sand dykes had been constructed, then dune arches would have probably meanwhile developed on Terschelling, Ameland and Schiermonnikoog anyway. From that perspective, interfering in the present situation is not necessarily necessary. However, without the drift-sand dykes, the island tails would have had larger washover complexes, a more jagged course of dune rows and more gradients than is presently the case. This may be reason to intervene. Concerning the management option 'do nothing', large-scale rejuvenation can only occur in or following a situation of large-scale erosion. As it is, a considerable amount of sand is stored at many locations in the drift-sand dyke. Without large-scale erosion, it can be considered to restore a more natural situation by means of active interference. There are, however, limits to what can be achieved in this way, because the dynamic geomorphological processes in the begin phases, which are responsible for the variation of the landscape, cannot always be restored on a large scale in the later phases of the succession.

There are many ways to intervene on the island tails for reasons of management. The results of some are fairly predictable (grazing, for example), while the results of other interventions are still difficult to predict (making an opening in a drift-sand dyke, for example). Major, new interventions, such as the restoration of washovers, must first be carried out as a pilot. A good monitoring system is indispensable, so that lessons can be learned from the results and changes can be made where necessary. Based on model studies, most of the measures proposed here are not expected to have any effect on water safety. Measures that influence the immediate foreland of a dam on the islands may in some cases result in a greater pounding of the waves on the dam. This should be taken into consideration per individual measure.

The various elements of the island tails came about in coherence and influence one another in the course of their development. Even if individual elements require customized measures, (a sandy green beach and a clay-rich salt marsh, for example, require different management measures), this coherence should always be taken into account in the management of the island tails.

The Natura 2000 system does not distinguish between all of the elements of the island tail, nor does it recognize the correlation between all of the elements. A better understanding of the system of an island tail can hopefully generate more attention for the natural functioning and the coherence of the development on various scales of space and time.

Rapport nr. 2015/OBN198-DK:
Ontwikkeling van eilandstaarten - Geomorfologie, waterhuishouding en vegetatie