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# Options for dynamic coastal management

# A guide for managers

**Deltares, Bureau Landwijzer, Rijkswaterstaat Centre for Water Management**

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1207724-000

**Title**
Options for dynamic coastal management
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| Client | Project | Reference | Pages |
|---|---|---|---|
| Rijkswaterstaat Centre for Water Management | 1207724-000 | 1207724-000-ZKS-0011 | 35 |

**Keywords**
Coastal maintenance; dynamic coastal management; dunes; foredune; coast; flood defences

**Summary**
Annual sand nourishment operations maintain the coastline and supplement the coastal foundation so that it can match sea-level rise. The coastal foundation consists of the shore face, the beach and the dunes (and the hard flood defences they contain). In practice, the dunes are the least active part of the coastal foundation, mainly as a result of foredune management, which interferes with sand transport to the dunes in many locations. As a result, the dunes have been, as it were, disconnected from the dynamic coastal system. Allowing sand to drift in to the foredune where possible will allow the dunes to re-acquire an active role in the coastal foundation and therefore match sea-level rise. This will extend dynamic coastal management to the entire coastal foundation.

The specifics of the management approach will vary according to the location. The management authorities will need to elaborate the approach in consultation with those involved, such as the provincial authorities, municipal authorities and other stakeholders. This guide provides a 'phased plan' that managers can use during that process.

It distinguishes between different types of coast: *island heads*, *island tails*, *narrow dunes*, *wide dunes*, *accretion coastlines*, *coastal towns*, *dams and dikes in the sand*, and *transition structures*. In addition, the guide recognises different levels of dynamism, with increasing degrees of latitude for natural processes: *embryonic dunes*, *blowout foredune*, *gouged foredune*, *parabolic foredune*, *washover* and *slufter (intertidal dune area)*. This guide provides an indication of which levels of coastal dynamism are possible for the different types of coast, taking the boundary conditions into account (such as flood protection, other interests and the sand budget).

Finally, the guide emphasises the importance of communications with stakeholders at all the planning and implementation stages of dynamic coastal management, the monitoring of development and the resulting plan for interventions when developments take an undesirable course.

**References**
Photos: Rijkswaterstaat, Simon Warner, Bas Arens, Alterra, Moniek Löffler, Carola van Gelder
English translation: Pete Thomas

| Version | Date | Author | Initials | Review | Initials | Approval | Initials |
|---|---|---|---|---|---|---|---|
| 2 | may 2013 | M. Löffler<br>Dr. A.J.F. van der Spek<br>C. van Gelder-Maas | | Dr. L. van der Valk | | T. Schilperoort | |

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# 1 Introduction

## 1.1 Background

Dynamic coastal management: again and again, the concept emerges in plans for research, management and policy. The encouragement of this type of management is an action point in the Third Coastal Memorandum from 2000. This memorandum states that flood defence managers and area managers are responsible for actioning dynamic coastal management. However, an evaluation of the Third Coastal Memorandum (Ministry of Transport, Public Works and Water Management, 2007) shows that dynamic coastal management is not taking off as it should everywhere.

To understand the causes, and the problems faced by managers, Rijkswaterstaat and STOWA organised a workshop for managers in May 2010. During this workshop, the participants said that dynamic coastal management was important and that it should be continued. It also emerged that everybody had a different definition of dynamic coastal management and that the approaches varied according to the location. Often, flood defence managers find it awkward to determine the concrete options for dynamic coastal management in the areas they manage and to make a proper assessment of the consequences. In addition, it is difficult to explain to the general public what dynamic coastal management involves. Many residents and visitors to coastal areas have no clear idea of dynamic coastal management. They often feel that it isn't safe and often respond with objections. In addition, Natura 2000 has proven to be an awkward issue for some flood defence managers: what are the implications for the management of flood defences and how can the importance of flood defences be embedded in Natura 2000 management plans?

The conclusions of the workshop of May 2010 have been included in a vision report entitled 'Hoe verder met dynamisch kustbeheer?'[1] (STOWA, 2010). This document contains six action points on which STOWA and Rijkswaterstaat are working together:

*1. The production of a 'guide to dynamic coastal management' with clear definitions and options for the implementation of dynamic coastal management (while maintaining flood protection)*

It has emerged that ideas vary about the significance and the implementation of the concept of dynamic coastal management. In itself, this is not unusual because there are major differences as one moves along the Dutch coast, and different values and interests are involved in each area. That means that the options for dynamic coastal management also vary. A guide can help managers to take reasoned and transparent decisions about management, obviously while maintaining flood protection levels. A guide of this kind can look at the different options for dynamic coastal management and the applicable requirements. In each area, it is then possible to take a look with all those involved at the potential significance of dynamic coastal management for that location.

*2. The provision of information about the relationship between dynamic coastal management and Natura 2000*

It is important for managers to be well-informed about the relationship between coastal management and Natura 2000: Which measures are desirable, and which are not? What requirements can flood defence managers impose, for example with respect to the maintenance of flood defences, and what obligations do they have?

[1] *'Dynamic coastal management, the next step'*

*3. Clear communications*
The elimination of barriers between organisations and improved communications about what dynamic coastal management involves are a recurrent issue. Improved communications are required, both inside organisations and with the outside world.

Important objectives here are:
Generating interest and support for dynamic coastal management;
Making it clear that dynamic coastal management does not have any negative implications for levels of protection on condition that the boundary conditions are met;
The encouragement of dynamic coastal management in places where that is possible and desirable;
Working together with those involved inside and outside managers' own organisations: learn about each other's interests and understand each other's work!
These objectives *and* the way they can be achieved need to be elaborated in a communications strategy for dynamic coastal management. An important point here is that the managers have to be able to communicate clearly with the public and have the appropriate resources.

*4. Put good monitoring into place*
It is important for managers to have a better picture of the volume of sand in the foredune. That is a precondition for flexible management because it makes managers' room for manoeuvre clear. It is useful to look at the techniques that are feasible and/or available for this purpose.

*5. Coordinating knowledge agendas*
In the future, coastal development will become increasingly integrated. The Coast Sub-Programme of the Delta Programme has drawn up a national framework for coastal development, the National Coast Framework. This framework states, among other things, that nourishment should fulfil more functions in the future than only the management and maintenance of the coastline and the coastal foundation. It takes into account the different functions fulfilled by the coast, including its role in nature. To shape this new approach, research is being conducted, for example in the Alternative Long-Term Nourishment Strategies. Other government authorities and bodies have their own knowledge agendas, often based on other objectives. The coordination of these knowledge agendas is urgently recommended and a joint approach should be adopted to provide users with access to knowledge. Collaboration, clarity *and* coordination are needed for the implementation of integrated coastal policy!

*6. Ad hoc questions*
Finally, the ad hoc questions faced by managers should not be pushed into the background. That means that an answer is needed to questions such as:
- What approach is needed to bunkers?
- What should be the approach to the distances between beach pavilions and the size of those pavilions (both height and width)?
- What should be the approach to the distance between beach pavilions and beach huts from the dune foot, and what should be the approach to the foundation method?
- How can recreation policies (for which municipalities are responsible) and flood defences (the responsibility of water authorities) be combined?
- What should be the approach to sand drift submerging infrastructure and the associated costs?
- What approach is needed to blowouts?

- What approach is needed to groynes?

One idea is to open up questions of this kind, with the associated answers, in a list of FAQs on the site www.dynamischkustbeheer.nl.

## 1.2 This guide

The document you are reading is the result of the first action point: the drafting of a guide for dynamic coastal management. This document is not a blueprint for dynamic coastal management. It does supply clear definitions (see chapter 2) and provides a sketch of the reasons and transparent 'options' for dynamic coastal management. It is of course up to managers to elaborate these things in consultation with other stakeholders at the regional level in a management plan. This guide provides a 'phased plan' that managers can use during that process:

- What type of coast is involved and what are the boundary conditions in terms of protection, other interests and the sand budget? (see Chapter 3),
- What types of dynamics can be applied in different types of coast, what are the consequences and what measures can be taken? (Chapter 4), and
- What are the issues for implementation and planning? (Chapter 5).

This guide is based on vision documents, reports and studies addressing dynamic coastal management (see References). However, the definitions used often differ; this guide makes a selection of definitions (Chapter 2).

# 2 Dynamic coastal management

## 2.1 The coastal system

Our coast is constantly changing. Usually, the weather is calm, and waves and currents take sand from the surf zone to the beach. As a result, the beach gets bigger and, with the added factor of the wind, so do the dunes. But during stormy weather, the beach and the foredune lose sand to the sea. Once the storm passes, the sea brings the sand back to the coast. In addition to these processes, which are quite frequent, there are also large-scale processes that we cannot observe directly, such as sea-level rise and falling land levels. Even so, these processes have a major impact on the development of our coast. Because of relative sea-level rise, more sand is being moved from the North Sea coast to the Wadden Sea. As a result of this process of sand erosion, the coast is tending to move back in a landward direction. The rivers and the sea do not bring in enough sediment to compensate. The result is the structural erosion of the coastline.

## 2.2 Dynamic coastal management

To prevent structural erosion of the coast, it was decided in 1990 to maintain the position of the coastline by means of sand nourishment. In addition, since 2001, the sand buffers of the coastal foundation[2] have been maintained so that this foundation can match sea-level rise. This strategy is based on the dynamic interplay of the sea, sand and wind. Bringing new sand into the coastal area in time prevents sand shortages there so that the coastal foundation matches sea-level rise. Some of the nourishment sand drifts from the beach to the dunes and raises the foredune[3]. In addition, embryonic dunes can form in front of the foredune.
The amount of sand drifting and the distance it is blown land inwards depends on the type of foredune. Where the foredune is uninterrupted and densely vegetated, most of the sand is trapped in the marram. On the other hand, dynamic foredunes with blowouts and gouges act as a channel for sand to move into the hinterland (Ministry of Economic Affairs, Agriculture and Innovation, 2010). The foredune management determines the spatial extent of the impact of the sea on the backdunes.

In practice, the dunes are the least active part of the coastal foundation, mainly as a result of foredune management, which interferes with sand transport to the backdunes in many locations. As a result, the dunes have been, as it were, disconnected from the dynamic coastal system. Allowing sand to drift in to the foredune where possible will allow the dunes to re-acquire an active role in the coastal foundation and therefore match sea-level rise. This will extend dynamic coastal management to the entire coastal foundation.

Dynamic coastal management is defined in this guide as 'management focusing on making the outer dunes more dynamic in order to link the wet and dry parts of the coast. The aim is to make the coast more dynamic while maintaining protection levels.'

2 *The coastal foundation consists of the shore face, the beach and the dunes (and the hard flood defences they contain).*

3. *The foredune is the row of dunes closest to the sea.*

The specifics of the management approach will vary according to the location. The management authorities will need to elaborate the approach in consultation with those involved, such as the provincial authorities, municipal authorities and lobby organisations. In addition, the length of time it takes for the impact of dynamic coastal management to become apparent will vary. That depends on, among other things, the initial situation and the adopted measures. The prime element is: patience. Natural processes and the development of a natural landscape take time!

## 2.3 Policy objectives

The goal of dynamic coastal management is usually linked to both coastal protection and nature. The stated aims are:

*1. The boundary condition for the recovery and extension of a resilient coast (Third Coastal Memorandum, 2000)*
The Third Coastal Memorandum 'Tradition, Trends and the Future' was published in 2000. Dynamic coastal management is defined here as a boundary condition for the restoration and extension of coastal resilience. The coastal memorandum states that dynamic coastal management is being extended and includes the following action point: 'further encouragement of the dynamic management of the dunes. The initiative in this respect resides with the area and flood defence managers.'

*2. Ecological aims / contribution to the objectives of Natura 2000*
Processes forming landscapes such as sand drift and washover with salt water determine the development of the dune and coastal landscape. Steps are taken to prevent the ageing of vegetation and the number of transitional areas between fresh/salt, dry/wet, high/low or sandy/muddy is increasing. Re-introducing dynamism is seen as the most promising approach to preserving biodiversity in the long term. More information about the relationship between dynamism and biodiversity in the coastal and dune landscape can be found in the Preadvies Duin- en Kustlandschap (*Dune and Coastal Landscape Initial Advisory Report*, Ministry of Agriculture, Nature and Food Quality, 2009).
The maintenance and/or the development of many habitats are rooted in law. Almost the entire dune area has been designated as a Natura 2000 area and is covered by the Dutch Nature Conservancy Act. Tables 1 and 2 state which types of habitats and associated dynamics in the most seaward dunes require protection and the associated objectives.

*3. Contribution to sustainable protection: matching sea-level rise*
Where the coast is managed dynamically, the wind and/or sea can transport sand and mud further inland. As a result, it is easier for the outer dunes and tidal marshes in front of the dikes to match sea-level rise. Dynamic foredunes with blowouts and gouges act as channels for sand to move to the dunes located behind the foredune, which get bigger as a result; these dunes are part of the coastal foundation. At the moment, this process is often disrupted by the presence of a densely vegetated and stable foredune (Action Plan, Wadden Delta Programme, 2010).

*Table 1: goals of dry dynamic types of habitats in the most seaward foredunes (source: area database, Ministry of Economic Affairs, Agriculture and Innovation).*

| ***habitat (number)*** | **2110** | | **2120** | | **2130a** | | **2130b** | | **2130c** | |
|---|---|---|---|---|---|---|---|---|---|---|
| ***habitat (name)*** | **embryonic dunes** | | **white dunes** | | **grey dunes calcium-rich** | | **grey dunes calcium-poor** | | **grey dunes mat-grass swards** | |
| ***Natura 2000 objective*** | surface area | quality | surface area | quality | surface area | quality | surface area | quality | surface area | quality |
| ***Designated*** | | | | | | | | | | |
| Schiermonnikoog dunes | | | = | = | = | = | > | > | > | > |
| Ameland dunes | | | = | = | = | = | > | > | > | > |
| Terschelling dunes | = | = | = | = | = | = | > | > | > | > |
| Vlieland dunes | | | = | = | = | = | > | > | = | = |
| Texel dunes and low-lying areas | = | = | = | = | > | > | > | > | > | > |
| Schoorl dunes | > | = | > | > | = | = | > | > | | |
| Coepelduynen | | | = | > | = | = | | | | |
| Voornes dune | | | = | = | > | > | | | > | > |
| Goeree en Kwade Hoek dunes | = | = | = | = | > | > | = | = | = | > |
| Zwin | = | = | = | > | = | = | | | | |
| ***designated in concept*** | | | | | | | | | | |
| Den Helder and Callantsoog dunes | | | = | > | = | = | = | = | = | = |
| Zwanenwater and Pettemer dunes | | | = | > | | | > | > | > | > |
| North Holland Dune Reserve | | | > | > | > | > | > | > | > | > |
| Kennemerland-Zuid | = | = | > | > | > | > | = | > | > | > |
| Meijendel and Berkheide | | | = | > | > | > | > | > | | |
| Westduinpark and Wapendal | | | | | > | > | | | | |
| Solleveld and Kapittel dunes | | | = | = | = | > | = | > | | |
| Kop van Schouwen | = | = | > | > | > | > | > | > | > | > |
| Manteling van Walcheren | | | | | | | > | > | | |

| | |
|---|---|
| = | maintenance of surface area / maintenance of quality |
| > | extension of surface area / improvement in quality |

*Table 2: goals of dynamic saltmarsh habitats (source: area database, Ministry of Economic Affairs, Agriculture and Innovation).*

| ***habitat (number)*** | **1310a** | | **1310b** | | **1330a** | | **1330b** | |
|---|---|---|---|---|---|---|---|---|
| ***habitat (name)*** | **pioneer vegetation marsh samphire (*Salicornia*)** | | **pioneer vegetation sea pearlwort (*Sagina maritima*)** | | **grasslands in front of the dike** | | **grasslands behind the dike** | |
| ***Natura 2000 objective*** | surface area | quality | surface area | quality | surface area | quality | surface area | quality |
| ***designated*** | | | | | | | | |
| Schiermonnikoog dunes | | | | | | | | |
| Ameland dunes | | | | | | | | |
| Terschelling dunes | = | = | = | = | | | | |
| Vlieland dunes | = | = | = | = | = | = | | |
| Texel dunes and low-lying areas | = | = | = | = | = | = | = | = |
| Schoorl dunes | | | | | | | | |
| Coepelduynen | | | | | | | | |
| Voornes dune | | | | | | | | |
| Goeree en Kwade Hoek dunes | = | = | = | = | = | = | | |
| Zwin | = | = | | | = | = | = | = |
| ***designated in concept*** | | | | | | | | |
| Den Helder and Callantsoog dunes | | | | | | | | |
| Zwanenwater and Pettemer dunes | | | | | | | | |
| North Holland Dune Reserve | | | | | | | | |
| Kennemerland-Zuid | | | = | = | = | = | | |
| Meijendel and Berkheide | | | | | | | | |
| Westduinpark and Wapendal | | | | | | | | |
| Solleveld and Kapittel dunes | | | | | | | | |
| Kop van Schouwen | | | | | | | | |
| Manteling van Walcheren | | | | | | | | |

| | |
|---|---|
| = | maintenance of surface area / maintenance of quality |
| > | extension of surface area / improvement in quality |

***Box: Natura 2000 habitats relevant for dynamic coastal management. Each habitat is subject to maintenance and/or improvement objectives.***

- *Embryonic dunes* (habitat 2110). These are partly vegetated low dunes on the backshore. They can be found on accreting or stable coasts and they constitute the early phase of primary dune formation. Embryonic dune formation starts with sand couch (Elytrigia juncea subsp. boreoatlantica), which germinates on the beach and then begins to trap sand. Embryonic dunes are often washed away in whole or in part during storms.

→ In approximately half of the dune areas designated as Natura 2000 areas, the maintenance of the area and/or the quality of embryonic dunes is the policy goal.

- *White dunes* (habitat 2120). The term 'white dunes' refers to the colour of the sand: because no soil has developed yet, the sand is still white rather than grey. White dunes can be found in the outer dunes, where inblowing salt and drifting sand create an extreme environment where only few plant species can survive. The most dynamic locations consist of a mixture of high grass tussocks and bare sand, with vital marram predominating.

→ In approximately half of the dune areas designated as Natura 2000 areas, the maintenance of the area and/or the quality of embryonic dunes is the goal. In the other half of the areas, the surface area has to be maintained or extended *and* the quality of the habitat must be improved.

- *Grey dunes* (habitat H2130). Grey dunes consist primarily of dry grasslands with species-rich vegetation comprising short grass, herbs, mosses and/or lichens. They are usually particularly rich in plant species. The sustainable preservation of this habitat depends on sand drifting in regularly. Without this dynamism, the probability increases that vegetation will age and become clogged with shrubs.

→ In virtually all dune areas designated as Natura 2000 areas, the area of grey dunes is being extended and the quality of the habitat is being improved.

- *Pioneer saltmarsh vegetation* (H1310). This habitat includes pioneer vegetation along the coast where land and sea meet. Marsh samphire is the characteristic species. For the preservation of this habitat, moderate dynamism is needed in the form of washover with salt water.

→ For a few coastal areas (particularly in the Frisian Islands and in Zeeland) the Natura 2000 objective is: maintenance of surface area and quality.

- *Salt marshes and salt grasslands* (H1330). This type of habitat comprises salt marshes in front of the dikes that the sea regularly washes over, and areas behind the dikes that are affected, or have been affected, by salt water. Characteristic species for this habitat are sea lavender (*Limonium vulgare*), common saltmarsh grass (*Puccinellia maritima*), sea purslane (*Atriplex portulacoides*) and sea couch (*Elymus athericus*).

→ Here also, only a few coastal areas (in the Frisian Islands and in Zeeland) are covered by the Natura 2000 objective: maintenance of surface area and quality.

# 3 What can be done, and where?

## 3.1 Introduction

This chapter describes the stages that managers can go through to determine which type of dynamic is possible and where. This varies from place to place. The priority is the maintenance of flood protection and it is very important here whether the dunes are narrow or broad, whether there are buildings and whether the dunes are used as a source for water supplies.

That is why the exploration of the options for dynamic coastal management begins with the description of the initial situation. Flood defence managers, in consultation with other stakeholders, can then determine which boundary conditions apply to that area in terms of flood protection and other types of land use.

These data establish a picture of the available options discussed in Chapter 4.

## 3.2 What is the initial situation

The sandy part of the Dutch coast is typified by a succession of different types of coast. This guide distinguishes between the following types of coast:

- *Island head*, the broad part of an island that captures sand directly from the ebb-tidal delta;[4]
- *Island tail*, the narrow part of an island that does not receive sand from the ebb-tidal delta;
- *Narrow dunes*, dunes that consist of one or two rows of dunes;
- *Wide dunes*, dunes that consist of more than two rows of dunes;
- *Accretion coastlines*, parts of the coast that are built up, whether or not as the result of natural processes;
- *Coastal towns*, which are located directly at the sea or separated from it by a narrow row of dunes;
- *Dams and dikes* reinforced with sand or covered by sand as a result of natural processes; and
- *Transition structures* between dikes and breakwaters and dunes.

These types of coast are described in detail below.

4. *The ebb-tidal delta is the shallow bar area found on the seaward side of a tidal inlet.*

| | | |
|---|---|---|
| Island heads | An island head is the end (usually western or southwestern) of a Frisian Island, where sand is brought in from the ebb-tidal delta. If one looks at the Frisian Islands from a large height, one sees that this island head is often the widest part of the island. Development here is the result of age-old processes of accretion and erosion. The remarkable thing about island heads is that this long-term development process includes a shorter cycle of sand accretion and erosion. A cycle of this type often lasts between 50 and 100 years, with tidal channels eroding the coast at one time and large sand shoals making up for this loss at others. A beach will often be very wide for a time after a sand shoal reaches the shore, as is the case at present with the northwest coast of Ameland and Schiermonnikoog (source: Eilanden Natuurlijk, 2008). |  <br>*Noordvaarder, Terschelling* |
| Island tails | An island tail can be found on the eastern side of many Frisian islands. By contrast with the island head, no sand is actually transported directly here from the ebb-tidal delta. As a result, there is less sand available in relative terms. An island tail consists of a bare, dynamic sand beach with successive periods of accretion and erosion. The behaviour of this 'waggly' tail is closely linked to the cyclical movements of the channels in the tidal inlet alongside it. The wind blows sand so that it forms embryonic dunes on |  <br>*East Ameland* |

| | | |
|---|---|---|
| | the beach. If there is enough sand and the island tail grows, the small dunes on the beach get larger and larger and finally merge to form a gouged foredune. In the past, artificial drift dikes were created by, for example, planting marram grass. A salt marsh often forms in the shadow of the foredune. | |
| Narrow dunes | These are dunes that are some hundreds of metres wide. The exact width depends on the area and cannot be stated exactly. There are different categories:<br>- The dunes consist of a single row of dunes only. The erosion zone and limit profile[5] together just comply with the statutory requirement. All the sand in place is required to provide flood protection.<br>- The dunes consist of two rows of dunes or of several low/narrow rows of dunes. The erosion zone and limit profile are well within the statutory requirements. There is slightly more sand in place than is needed to provide primary flood protection. |  <br>*Walcheren* |

[5] *Limit profile: the minimum profile that must be present to provide flood protection after dune erosion in design conditions.*

| | | |
|---|---|---|
| Wide dunes | Wide dunes are hundreds of metres or kilometres wide; there is much more sand in place than is required for the purposes of flood protection. Behind the erosion zone, the limit profile and the reserve dunes, there is a dune area that does not formally 'count' for the purposes of protection. |  |
| Accretion coastlines | These are sections of the coast where sand is deposited in a natural way and that expand seaward, or sections of the coast that are extended seaward in artificial ways.<br>Examples: northwestern coast of Goeree, the Sand Motor near Delfland. |  <br>*Northwestern coast of Goeree* |
| Coastal towns | In the case of coastal towns, a distinction can be made between two situations:<br><br>1. Coastal towns with an 'open link' to the sea (such as a promenade).<br>Examples: Bergen, Egmond, Zandvoort, Noordwijk, Katwijk, Scheveningen, Kijkduin, Domburg, Vlissingen.<br><br>2. Coastal towns separated from the sea by a narrow row of dunes.<br>Examples: Callantsoog, Oostkapelle, Zoutelande, Cadzand-Bad, Breskens. |  <br>*Noordwijk aan Zee*<br>  <br>*Callantsoog* |

| | | |
|---|---|---|
| Dams and dikes in sand | These are dams and dikes strengthened with sand or where sand has accreted spontaneously. In some cases, the sand forms new dunes on the dam. Examples: Ter Heijde, Noordwijk, Nieuwvliet-Groede, Breskens-Oost, Veerse Gatdam, Brouwersdam. |  *Veerse Gatdam* |
| Dunes linked up to dikes and breakwaters (transition structures) | These are dunes that are linked to dikes or breakwaters. These are weak points in the flood defences. Examples: Schoneveld, Cadzand-Oost, Helderse zeedijk, Hondsbossche Zeewering, Pettemer Zeewering. |  *Transition dunes - Hondsbossche Zeewering sea dike* |

## 3.3 What are the boundary conditions?

3.3.1 Boundary conditions for the purposes of flood protection

Dynamic coastal management is only permissible if flood protection levels are not affected. This depends on the location of the flood defences in the dune area, and on the height and width of the flood defences.

This guide distinguishes between three situations, with the sand budget as the underlying principle:

1 All the sand in place is required to provide flood protection;
2 There is more sand in place than is required for the purposes of flood protection; and
3 There is excess sand.

These situations are discussed below.

*1. All the sand in place is required to provide flood protection*

The dunes are narrow: the erosion zone and limit profile together just comply with the statutory requirement. The types of coast where this situation is found are:

- Coastal towns with or without an 'open' link to the sea;
- Narrow dunes consisting of a single row of dunes;
- A number of dams and dikes enclosed in sand; for a number of dike upgrade projects, there is exactly enough sand in place to meet the flood protection requirement. There is therefore little excess sand and sand drift is not possible.
- Transition structures between dikes and dunes.

In the case of narrow dunes, sand drift may be 'deployed' to create a more robust foredune with a larger volume of sand and vital marram tussocks (see box below).

***Box: dynamic coastal management near Callantsoog***

*In early 2000, the Hoogheemraadschap Hollands Noorderkwartier water authority introduced dynamic coastal management in the high foredune fronting Callantsoog. This foredune was located in the shadow of embryonic dunes, as a result of which only small amounts of sand were blown into it from the beach. The shortage of fresh beach sand meant that marram grass grew poorly in the foredune and was becoming less and less vital. Instead, large amounts of moss were growing on the outer side of the foredune.*
*To ensure that sand could drift in to the foredune again, to return the marram to a healthy condition and to ensure that the foredune would capture sand again, the flood defence manager integrated the embryonic dunes and the foredune into a single profile. As a result, after some time, marram began to grow spontaneously in the dune foot and slowly spread upwards. Consequently, more sand was captured again and an additional sand buffer was created for the flood defences. It took a number of years and some explanations were necessary but the result is that the dune in front of Callantsoog is again fully covered with healthy marram and has extended to some extent in a seaward direction.*

*2. There is more sand in place than is required for the purposes of flood protection*
The erosion zone and limit profile comply with the statutory requirements and there is enough sand in place that can be blown away without affecting the limit profile. Types of coast where this is a feature are:
- Narrow dune areas consisting of several rows of dunes;
- A number of dams and dikes enclosed in sand.

*3. There is excess sand*
The dunes are broad and there is much more sand in place than is required for the purposes of flood protection. There are openings for defining the unbroken limit profile landward of the present limit profile. Excess sand can be found in the following types of coast:
- Wide dunes;
- Island tails;
- Island heads;
- A number of dams and dikes enclosed in sand, with spontaneous dune formation;
- Accretion coastlines;
- Coastal expansion.

### 3.3.2 Boundary conditions associated with other interests

Whether dynamic coastal management is permissible or not also depends on other interests. They comprise land use of the land behind the dike such as agriculture, coastal towns (recreation) or infrastructure and interests in the dune area itself such as nature, the use of the dune area as a source for water supplies, gas extraction, recreation or infrastructure.
The options for dynamic coastal management are also related to the presence of beach pavilions and beach huts. The effect of built-up areas in front of the foredune is currently being studied in more detail and is not covered by this guide.

### 3.3.3 Sand budget as a boundary condition

The options for dynamic coastal management are very much helped by sand nourishment. It maintains adequate quantities of sand in the coastal system and ensures that sand drift does not adversely affect flood protection. It raises the volume of sand in the surf zone and on the beach. The beach becomes wider as a result but, as a result of the extension of the dune foot and coastal erosion, the beach gets narrower with time.

Determining the options for dynamic coastal management in conjunction with the management strategy requires tailored local solutions. An important source of information here is experience with nourishment operations in the past and the impact they have had on the local history of coastal development.

# 4 Options

## 4.1 Introduction

Once there is a clear picture of the initial situation and the boundary conditions, the flood defence manager can, in consultation with other stakeholders, decide which types of dynamic are possible in the area in question. This guide distinguishes between six types of dynamic:

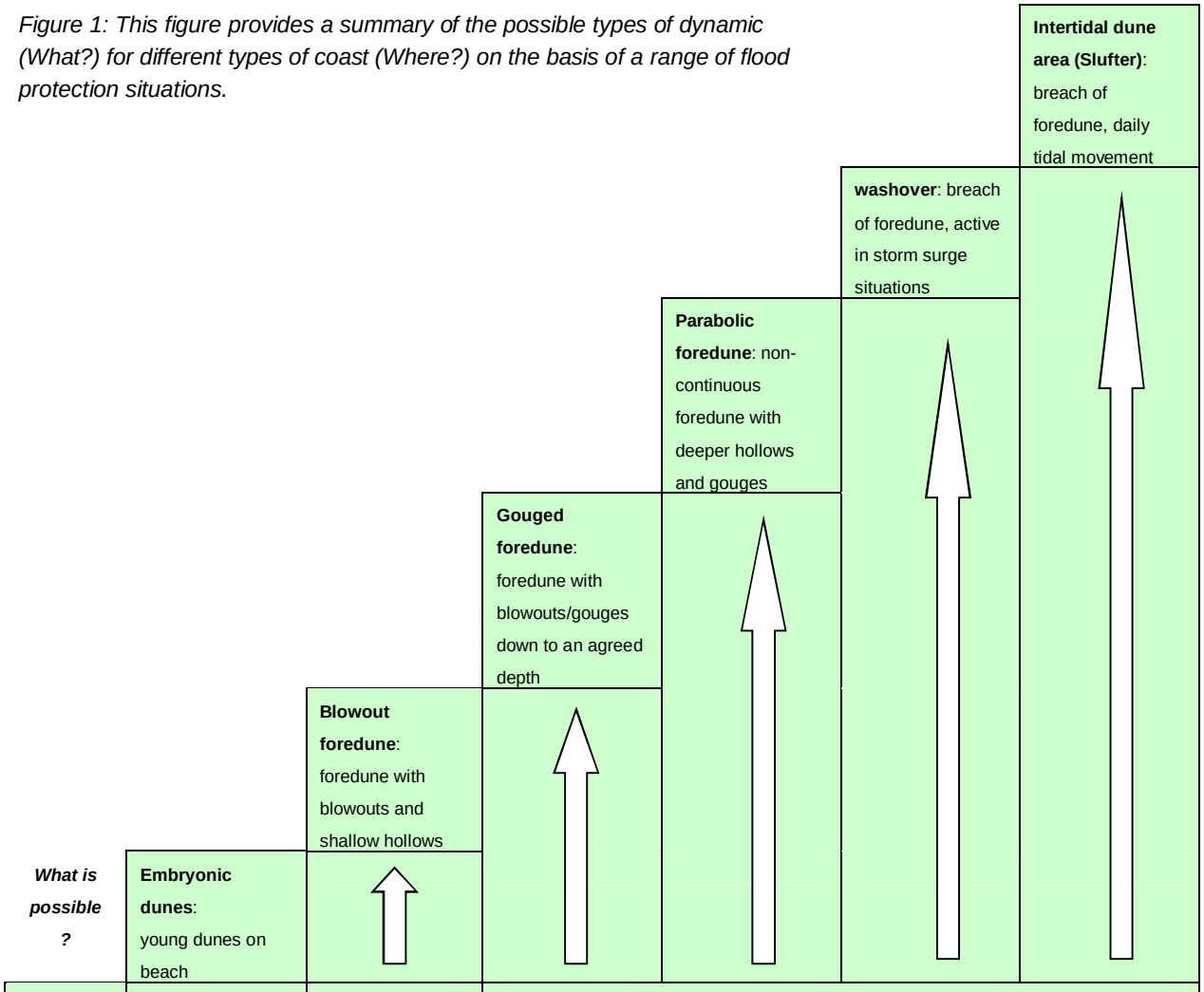
1. *Embryonic dunes*: young dunes on the beach;
2. *Blowout foredune*: foredune with blowouts and shallow hollows;
3. *Gouged foredune*: foredune with blowouts/gouges down to an agreed depth;
4. *Parabolic foredune*: non-continuous foredune with deeper hollows;
5. *Washover*: opening in foredune that is only submerged when the tidal level is high (as with spring and storm tides);
6. *Intertidal dune area (Slufter)*: breach of the foredune, daily tidal movement.

The different types are not static and can merge into one another. The level of dynamism and the size of the area affected increase from 1. to 6. These types of dynamic will be described more extensively later in this chapter. Table 3 and Figure 1 list the types of dynamic that are possible in the light of the sand budget and the initial situation. All types result in an increase in the volume of sediment in the coastal foundation.

*Table 3: indication of possible types of dynamic in each situation*

| ***flood protection*** | ***type of coast*** | ***types of dynamic*** | | | | | |
|---|---|---|---|---|---|---|---|
| **sand budget** | **initial situation** | **embryonic dunes** | **blowout foredune** | **gouged foredune** | **parabolic foredune** | **washover** | **intertidal dune area (Slufter)** |
| all the sand in place is required to provide flood protection | coastal towns with or without an open link to the sea | x | | | | | |
| | narrow dunes consisting of a single row of dunes | x | | | | | |
| | dams and dikes in sand | x | | | | | |
| | transition structures | x | | | | | |
| more sand present than is needed for flood protection | narrow dune area consisting of several rows of dunes | x | x | | | | |
| | dams and dikes in sand | x | x | | | | |
| excess sand / limit profile can be moved land inwards | wide dunes | x | x | x | x | x | x |
| | island tails | x | x | x | | x | x |
| | island heads | x | x | x | x | x | x |
| | accretion coastlines | x | x | x | x | x | x |
| | coastal expansion | x | x | x | x | x | x |

*Figure 1: This figure provides a summary of the possible types of dynamic (What?) for different types of coast (Where?) on the basis of a range of flood protection situations.*




| | | | | | | |
|---|---|---|---|---|---|---|
| ***Flood protection situation*** | In all situations | If more sand is present than necessary for flood protection | Only if there is excess sand | | | |
| ***Where possible ?*** | Coastal towns<br>Narrow dunes: one row of dunes<br>Dams and dikes in sand<br>Transition structures<br>Narrow dune area with several rows of dunes<br>Wide dunes<br>Island tails Island heads<br>Accretion coastlines<br>Coastal expansion | Dams and dikes in sand<br>Narrow dune area with several rows of dunes<br>Wide dunes<br>Island tails Island heads<br>Accretion coast<br>Coastal expansion | Wide dunes<br>Island tails Island heads<br>Accretion coast<br>Coastal expansion | Wide dunes<br>Island heads<br>Accretion coast<br>Coastal expansion | Wide dunes<br>Island tails Island heads<br>Accretion coast<br>Coastal expansion | Wide dunes<br>Island tails Island heads<br>Accretion coast<br>Coastal expansion |

## 4.2 Types of dynamic and their added value

This chapter describes six forms of dynamic and their added value. In addition, it looks at the options available for these types of dynamic, the steps that managers can take and the potential consequences of allowing dynamism.

### 4.2.1 Embryonic dunes

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| *Description*<br>These are partly vegetated low dunes on the backshore and the outer edge of the foredune. They represent the early phase of dune formation. Dune formation often starts when drifting sand covers debris washed up onto the beach such as seaweed and shells (on the drift line). This is the location for the germination of sand couch, a species that traps large quantities of sand and is essential for dune formation. As soon as the dune starts to hold fresh water, marram can also move in.<br>Embryonic dunes are salty and extremely dynamic. They are home to few plants and animals that can survive in these areas but the species that do manage to survive are often special. Characteristic plant species include sea sandwort (*Honckenya peploides*), perennial sowthistle (*Sonchus arvensis*), sea spurge (*Euphorbia paralias*) and Lyme grass (*Leymus arenarius*), and sometimes sea holly (*Eryngium maritimum*). The animals that live in these locations are mainly small invertebrates such as various types of beetle. Furthermore, if the area is quiet enough, birds such as the Kentish plover (*Charadrius alexandrinus*), common ringed plover (*Charadrius hiaticula*) and little tern (*Sternula albifrons*) may nest here.<br>Embryonic dunes often have a short life because the sea washes them away during severe storms or as a result of spring tides. The process of dune formation then starts again in the same place or elsewhere. Sometimes, however, the dunes get higher and higher, and merge to form a longer chain: a 'new foredune'. This new foredune is classified as a *white dune* habitat (see Chapter 2). The original foredune is then located in the shadow of the new dunes and will become less dynamic in time. It is expected that, as a result, less sand will drift into the dunes behind the original foredune. |  |

*Objectives*

*1. Objectives for flood protection*
- The creation of a buffer for protection purposes and the extension of the dune foot (preventing the erosion of the outer slope of the primary flood defence);
- The coastal foundation matches sea-level rise (to a limited extent).

*2. Objectives for 'nature'*
- Enhancing landscape quality;
- Maintenance and/or expansion of the surface area covered by *embryonic dunes*;
- Maintenance and/or improvement of the quality of the habitat type *embryonic dunes*;
- The new dunes are visible and recognisable. As a result, they contribute to the establishment of support from the general public for dynamic coastal management.

*Measures / management*
The formation of small new dunes can be furthered by:
- Leaving drift lines on the beach. At the moment, particularly in the tourist season and near coastal towns, they are removed frequently (often by machines).
- The limitation or prevention of traffic on, or intensive pedestrian access to, the backshore. This can interfere with the formation of embryonic dunes;
- The limitation of obstacles to the dune foot, such as beach huts and pavilions. They can have a negative impact on the formation of embryonic dunes.

*Areas requiring attention*
- Beach pavilions can be faced with the problem of drifting sand submerging foundation piles or with changes in accessibility. Clear communications with pavilion owners about the implications of dynamic coastal management are therefore essential.

### 4.2.2 Blowout foredune

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| *Description*<br>This type of foredune typically suffers from a certain degree of sand drift. The open vegetation cover consists primarily of marram, interspersed with blowouts and shallow hollows. This means that the form and height of the foredune vary. The marram grass forms vital tussocks: as a result of the regular wind drift of fresh beach sand and salt spray,[6] fungi and nematods find it more difficult to attack the roots of marram grass than in a foredune with dense vegetation. Some sand drifts into the area behind the foredune.<br>The blowout foredune forms *white dunes*.<br>Characteristic plant species include marram, hybrid marram, Lyme grass and marsh sowthistle. In addition, the blowout foredune provides a habitat for a range of beetle species and a number of exclusive fungi (Ministry of Agriculture, Nature and Food Quality, 2009). |  |

6. *Salt spray consists of fine drops of salt water which are formed during the misting of splashing water as waves break.*

*Objectives*

*1. Objectives for flood protection*

- Encouraging the vitality of marram for the purposes of robust flood defences;
- Encouraging the growth of dunes immediately behind the foredune;

Allowing the dune area (as a part of the coastal foundation) to match sea-level rise (to a limited extent).

*2. Objectives for 'nature'*

- Maintenance and/or expansion of the surface area covered by *white dunes*;
- Maintenance and/or improvement of the quality of the habitat type *white dunes*.

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*Measures / management*

- Spreading out foredune management measures (no sand screens, less planting of marram).
- Despite the spreading out of management measures, stable foredunes can often retain their character for long periods of time. This is probably linked to low numbers of severe storms. In that case, the desired development can be encouraged by targeted interventions such as removing vegetation.

*Areas requiring attention*

- Of course, the hollows must not be eroded so deeply that the flood defences are affected. So it is important to determine beforehand the extent to which sand drift is acceptable and when to intervene (and in what ways). Monitoring is essential to check whether blowout is still within the limits determined beforehand (see Chapter 5).
- Sand drift can impact, for example, infrastructure, beach pavilions or certain types of nature. Consultations in advance and good coordination with the users and managers of beaches and dunes are therefore important.

### 4.2.3 Gouged foredune

*Description*

In a gouged foredune, dynamism is stronger than in a blowout foredune. Here, deeper blowouts or gouges form. In the case of a gouged foredune, agreements are made in advance about how deep the gouges 'may' be. That can vary depending on the location. In North Holland, for example, the lower limit has been set at NAP + 7.50 metres (HH Uitwaterende Sluizen, 1998); in Delfland, the limit is NAP + 10 metres (HH Delfland, 2001).

Like the blowout foredune, the gouged foredune belongs to the category of *white dunes*. Biodiversity is exceptionally low here, although there are a number of characteristics plants and animals, including a number of exclusive fungi. In terms of processes, the gouged foredune is an important element in the coastal dunes: the gouges act as channels that the sand moves through. Here, there is a balance between the 'input' of beach sand and the 'output' of sand to the dunes behind the foredune. The drifting sand smothers older dune

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| vegetation, which then makes way for pioneer vegetation (Ministry of Agriculture, Nature and Food Quality, 2009). A certain amount of drifting sand is essential for the maintenance of the *grey dunes* habitat: dune grasslands that are rich in flora and fauna. | |

*Objectives*

*1. Objectives for flood protection*
- Encouraging the vitality of marram for the purposes of robust flood defences;
- Allowing the dune area (as a part of the coastal foundation) to match sea-level rise.

*2. Objectives for 'nature'*
- Rejuvenation of vegetation in the backdunes as a result of sand transport;
- Enhancing the natural character of the coast (more landscape variation);
- Maintenance and/or expansion of the surface area covered by *white dunes* and *grey dunes*;
- Maintenance and/or improvement of the quality of the habitat types *white dunes* and *grey dunes*.

*Measures / management*
- Spreading out of foredune management measures: no positioning of sand screens, less planting of marram, not positioning fencing;
- Despite the spreading out of management measures, stable foredunes can often retain their character for long periods of time. Development may be accelerated by moving dune crests land inwards using a crane or bulldozer.

*Areas requiring attention*
- Of course, the hollows must not be eroded so deeply that the flood defences are affected. So it is important to determine beforehand the extent to which sand drift is acceptable and when to intervene (and in what ways). Monitoring is essential to check whether erosion is still within the limits determined beforehand (see Chapter 5).
- Sand drift can impact, for example, infrastructure, beach pavilions or certain types of nature. Consultations in advance and good coordination with the users and managers of beaches and dunes are therefore important.

### 4.2.4 Parabolic foredune

*Description*

In a parabolic foredune, the wind is not constrained and deeper blowouts and gouges form. No lower limit is required here. This is only possible in wide dune areas where protection levels are safeguarded (in other words, when the limit profile is set more land inwards) and where drift does not interfere with other forms of land use. If the wind blows sand into the dune area from the beach, the mounds of sand may 'wander' through the dune area. This process is known as parabolisation. Typically, a parabolic foredune is non-continuous and topographic variation is considerable.

Like the blowout foredune and the gouged foredune, the parabolic foredune belongs to the category of *white dunes*. Here also, biodiversity is relatively low but the process is important for the entire dune area. The dune slacks act as channels for sand to move through and contribute to the rejuvenation of the vegetation in the backdunes. If the dune slacks are blown out to a considerable depth, the sea may flow into the dunes on an occasional basis (see 4.2.5, Washover). Because the limit profile is located land inwards, this does not constitute a problem in terms of the level of flood protection.

*Objectives*

*1. Objectives for flood protection*

- Allowing the dune area (as a part of the coastal foundation) to match sea-level rise.

*2. Objectives for 'nature'*

- The formation of ‘wandering’ dunes behind the foredune as an important process in landscape formation;
- Rejuvenation of vegetation in the backdunes as a result of sand transport;
- Enhancement of the natural character of the coast and more landscape variation;
- Maintenance and/or expansion of the surface area covered by *white dunes* and *grey dunes*;
- Maintenance and/or improvement of the quality of the habitat types *white dunes* and *grey dunes*.

*Measures*

- Spreading out or termination of management measures (no measures restricting drift, no installation of fencing);
- Despite the spreading out of management measures, stable foredunes can often retain their character for long periods of time. Development may be accelerated by digging hollows or trenches using a crane or bulldozer.
- There has to be an uninterrupted limit profile, or one has to be defined (it is important to bear in mind the possibility of an extension to the area covered by strict Dutch laws and ordinances to protect water systems and water works (known as *de Keur*)).

*Areas requiring attention*

- Parabolic dunes lead to structural changes in the dune area in the long term, with consequences for things like infrastructure and types of habitat. Vegetation succession is drastically reversed.
- In parabolic dunes, the edges can get so low that there can be washovers during storms.
- It is important to determine beforehand which developments are acceptable and when to intervene (and in what ways). Monitoring is essential to check whether developments are remaining within the limits determined beforehand (see Chapter 5).
- Sand drift can impact, for example, infrastructure, beach pavilions and beach huts, or certain types of nature. Consultations in advance and good coordination with the users and managers of beaches and dunes are therefore important.

### 4.2.5 Washover

*Description*

Washover consists of a breach penetrating the foredune and a deposit area located behind it. Sometimes, this deposit area is surrounded by dunes, as in the case with De Kerf in North Holland, but there is usually no clear boundary and a lobate area is formed: the washover plain. A washover is active during storm surge situations: the sea enters the backdunes and deposits sand or mud there. On the Frisian Islands, we often see a spatial transition where washover plains turn into salt marshes that sometimes include a few drift dunes (Ministry of Agriculture, Nature and Food Quality, 2009).

Washovers can be found in accretion or erosion coastlines. The composition of the flora and fauna in a washover varies and depends on, for example, the frequency of flooding and the composition of the subsurface. In places with relatively little dynamism, algal mats can form that capture the sand to some extent. In even more sheltered locations, organic matter can accumulate and vegetation can move in consisting of salt-loving or salt-tolerant pioneer species such as marsh samphire (*Salicornia*), common saltmarsh grass (*Puccinellia maritima*) and saltmarsh rush (*Juncus gerardii*). Where the ground is brackish, succession starts with species such as seaside centaury (*Centaurium littorale*) and knotted pearlwort (*Sagina nodosa*). Even further outside the area affected by salt water, where fresh water seeps out of the backdune area, or where rainwater stagnates, colonisation by wet dune valley vegetation is possible.

*Objectives*

*1. Objectives for flood protection*
- The coastal foundation matches sea-level rise (to a limited extent).

*2. Objectives for 'nature'*
- Encouraging habitat and species diversity by:
  - increasing the number of gradients (fresh/salt, sand/mud, dry/wet). These gradients are less pronounced than in an intertidal dune area (Slufter);
  - rejuvenation of the vegetation as a result of vegetation being washed over or covered by drift sand.
- Maintenance of the surface area and the quality of the habitat type *pioneer saltmarsh vegetation* (H1310).

*Measures / management*
- Spreading out or termination of management measures (no measures restricting drift, no installation of fencing);
- There has to be an uninterrupted limit profile, or one has to be defined (needless to say, this does not apply to unprotected areas such as island tails);
- Agreements with managers of the local areas about the need for nourishment operations in the vicinity of a washover. If too much sand is brought in, the ground level in the breach of the foredune will be too high and the sea will no longer penetrate.

*Areas requiring attention*
- The frequency of the flooding of the backdunes depends on the height of the threshold and the high water levels. In conditions where sand drifts, the height of the threshold may vary.
- Waste and dirt from the sea can penetrate into the dunes or the salt marsh behind them (at high water);
- An increase in the amount of sand drifting through as a result of a washover can lead to changes in the vegetation in the salt marsh behind the foredune.

### 4.2.6 Intertidal dune areas (slufters)

*Description*
An intertidal dune area is a breach in the foredune where tidal water regularly flows into the area behind the dune through a channel that cuts across the beach (see photograph). There are intertidal dune areas in both erosion coasts (after a breach of the outer row of dunes) and accretion coasts (after the development of new dunes to the seaward side of the existing foredune, where the plain between the old and new foredune is partly cut off).
Two known intertidal dune areas are De Slufter on Texel and Het Zwin on the border between Zeeland and Vlaanderen.
Intertidal dune areas often include a wide variety of habitats: *Atlantic salt meadows* (H1330) in low sections, *pioneer saltmarsh vegetation* (H1310) in slightly higher sections, *humid dune slacks* (H2190)

De Slufter on Texel

| | |
|---|---|
| in places where groundwater seeps out and *dry dune vegetation* (H2110 or H2120) on the edges of the intertidal dune area. There is usually no vegetation in the most dynamic locations such as the beach and the mouth of the intertidal dune area. | |

*Objectives*

*1. Objectives for flood protection*

- The coastal foundation matches sea-level rise (to a limited extent).

*2. Objectives for 'nature'*

- Encouraging habitat and species diversity by:
  - increasing the number of gradients (fresh/salt, sand/sludge, wet/dry,);
  - rejuvenation of the vegetation as a result of vegetation being washed over/covered by drift sand.
- Maintenance of the surface area and the quality of the habitat *pioneer saltmarsh vegetation* (H1310).
- Maintenance of the surface area and the quality of the habitat *Atlantic salt meadows* (H1330).

*Measures / management*

- There has to be an uninterrupted limit profile, or one has to be defined (needless to say, this does not apply to unprotected areas such as island tails).
- Measures may be needed to limit the extent of the breach and the flood plain.
- Agreements with managers of the local areas about the need for nourishment operations in the vicinity of the mouth of the intertidal dune area. Large amounts of incoming sand can silt up the inlet. It should be pointed out that sand blocking the inlet can also be the result of natural sand transport. In the long term, most intertidal dune areas silt up naturally.

*Areas requiring attention*

- Waste and dirt from the sea can penetrate into the dunes (at high water).
- The position and the depth of the inlet channel can vary over time depending on the transportation of sand as a result of natural processes. If the inlet is too shallow, the penetration of tidal water can be reduced or even cut off in time. This results in the loss of the specific characteristics of an intertidal dune area.

# 5 Implementation and planning

## 5.1 Introduction

In the preceding chapters, we have looked at the different coastal dynamics and the relevant boundary conditions. This will allow managers, in consultation with stakeholders, to determine which types of dynamic they want to establish in a particular section of the coast. This chapter looks at the practical issues involved in the planning and implementation of dynamic coastal management. This involves communications, monitoring and intervention when developments take an undesirable direction. It is the responsibility of managers to elaborate these issues for specific areas in the management plan. It is important for managers and others involved in the management plan to develop the desired type of dynamic in a way that is as 'SMART' as possible. That means that the resulting plan must comply with the following requirements:

- Specific (susceptible to clear explanation);
- Measurable (possibility of checking after the event whether the goal has been achieved);
- Actionable (there must be activities associated with it);
- Realistic (the objective must be feasible);
- Time-bound.

This guide is an instrument for achieving this; concrete elaboration must be tailored to the specific circumstances and it will vary from place to place.

This chapter is based on, among other things, the results of a workshop about dynamic coastal management organised by STOWA and Rijkswaterstaat in September 2011. The theme of this workshop was 'Communications'. Most of those present were flood defence managers, dune managers, researchers and coastal policy officers. More information can be found about this workshop on the dynamic coastal management site (www.dynamischkustbeheer.nl).

## 5.2 Communications

### 5.2.1 Current situation

Managers have indicated that the number of questions and comments from the general public is constantly increasing. People want to get involved and they have clear opinions of their own. They recount that communications about management are better now than they were about 10 or 15 years ago. There is less resistance from one another of the kind that the parties have sometimes felt. There are positive stories about projects that have been set up by getting a lot of people involved. A good example is the recently adopted Coastal Memorandum from the Hoogheemraadschap Rijnland water authority. The involvement of approximately 200 people in the establishment of the memorandum was successful and it led to uniformity and support.

Even so, communications could be improved. For example:

- In the area of flood protection. There are often deeply rooted opinions ('myths') about flood protection and that makes it difficult to propose new approaches or new ideas.
- In the area of collaboration. There are often barriers between people and between organisations. Internal communications and collaboration are therefore an important issue;

- In the area of research. There is often little public support for research results. That is because researchers often communicate primarily with clients and because there is little opportunity for interaction with 'the public'. An issue here is that research is often conducted in a fragmented way in the form of projects, making it difficult for researchers to tell the 'big overall story'.
- In the area of policy and in the area of instruments. Central government determines policy and formulates the associated objectives but it does not go without saying that they will be implemented by other parties (particularly if the instruments or the financing are not in place).

5.2.2 Recommendations

To implement successful dynamic coastal management, good communications are essential. So it is important for a management plan to include a communications strategy with clear indications of objectives and resources for achieving those objectives. Everybody is responsible for this: it should not be left to the communications department. You do not need a specific academic background to communicate; everybody 'can do it'. The following recommendations can help during the development of the communications strategy:

*Be enthusiastic and involved!*

- Make sure that people feel they are being heard; then they won't feel surprised by a decision or feel they are victims of that decision.
- Make proposals concrete and show people what you are talking about; take people to visit a location, for example.
- Talk 'normally' and avoid jargon.
- Be honest and clear. Explain, for example, that there are limits to dynamic coastal management and that you will be monitoring developments closely and intervening if things go too far.
- Make sure you present a clear story, and a clear basic message. Make sure that everybody in the organisation tells that same story and that everybody is reading from the same page.
- Keep on communicating, and that also means after the completion of a project! People also see the results of an intervention and wonder whether expectations have been met.

*Work with stakeholders!*

- Map out the leading parties and their interests. This will involve, for example:
  - your own organisation (including the board);
  - co-users involved (dune managers, nature organisations, the recreational sector: beach pavilions and huts, hotels, promenades, camp sites);
  - Natura 2000 competent authority (including the provincial authority);
  - local and provincial governments, local and provincial political parties;
  - nature conservation organisations such as Stichting Duinbehoud, Waddenvereniging;
  - the public.
- Develop plans together with stakeholders and be understanding about each other's objectives. This results in the shared ownership of a plan or a change.
- Communicate about the plans together and tell the same story. People do not know who is responsible for what and they talk to the people who are easiest to contact. Make it clear that you are working together with several parties and ensure that the public do not feel they are being sent from pillar to post.

- Be cautious about 'throwing revolutionary ideas about' so that people can get used to them. People tend to want to stick with what they know and trust. So changes often provoke opposition, particularly if the changes and the implications are vague.

*Work on support for research!*

- Get stakeholders involved in the formation of research issues and use that as a way of responding to questions in society. The concept of simply 'transmitting' information is outdated.
- Assess public opinion by organising open days (current examples in the Netherlands are 'de Dag van de Dijk', the 'Dag van het Dynamisch Kustbeheer' or the 'Jaarlijkse Kustschouw').
- Make sure that information is clear and easy to find, for example through this guide and the site www.dynamischkustbeheer.nl .
- Provide as many concrete examples as possible of locations of dynamic coastal management where the impact can be seen.

*Communicate with managers in good time!*

- Make opportunities transparent. Explain clearly what is a project can deliver (in financial terms or in terms of social benefits) because this is important information for managers.
- Get to know the manager: make sure you know how he/she works and try to 'time' communications properly;
- Make sure that managers and civil servants interact effectively.
- Provide as many concrete examples as possible of locations of dynamic coastal management where the impact can be seen.
- A civil servant or administrator can be an excellent ambassador for an idea or a project!

## 5.3 Monitoring

A management plan should always include a monitoring programme with clear objectives, questions requiring answers and parameters to be monitored. It must also be clear when the results of the monitoring will lead to measures being taken. Important components of a monitoring programme include:

1 The goal of the monitoring and questions to be answered;
2 The parameters selected for monitoring and the methods and techniques; and
3 Available databases with monitoring data.

These components are discussed in further detail below.

### 5.3.1 The goal of the monitoring and questions to be answered

1. Identifying difficulties affecting flood protection or other functions
   Questions involved here include:

- Is the volume of sand in the flood defence falling?
- Is the profile of the foredune changing: are blowouts forming and, if so, where and how deep are they?
- What happens after a severe storm or a series of storms?
- Will an eroded dune recover as a result of natural sand accumulation?
- How much sand will drift over the foredune?
- What are the effects on other forms of land use?

- Will the drift remain manageable? Can it be stopped if necessary?
- Are changes to management required?

Here, it is important to describe the boundary conditions prior to monitoring in consultation with stakeholders. For example, at what depth does a gouge become a difficulty? This will vary depending on the situation.

2. Evaluating whether the dynamic coastal management objectives selected for the area have been achieved:

- What types of dynamic result? Does sand drift increase? Are blowouts formed? Are hollows forming and, if so, how deep are they? What are the effects on the ecology of the area behind?
- Have the expectations relating to dynamic coastal management been fulfilled and why/why not?
- Are adjustments to management required?

5.3.2 The parameters selected for monitoring and the methods and techniques

The selection of parameters depends on the questions that monitoring is intended to answer. Of course, other important factors include the desired accuracy of the data, the availability of data, the methods used to gather supplementary data and the costs of collection and analysis.

An important parameter is the *sand budget*, the condition of the sand buffers in a particular area. Possible methods used for these measurements are:

- Measuring beach and dune profiles with GPS (N.B. this is a labour-intensive approach);
- Using existing laser altimetry data collected annually; with GIS, these data can be used to determine sand volumes and the annual fluctuations in those volumes;
- Using satellite data (for example after a storm).

Other possible parameters are:

- Vegetation cover percentage;
- Vitality of marram;
- Number of blowouts and depth;
- Levels of drift cover;
- Washover flooding frequency;
- Types of vegetation;
- Species of fauna;
- Surface area covered by different types of habitat;
- Quality of different types of habitat.

5.3.3 Available databases with monitoring data

At present, data relevant to the monitoring of dynamic coastal management are collected in different ways:

- Data such as JARKUS (Annual Coastal measurements by Rijkswaterstaat) section information are collected annually at the national level. In addition, altitude data covering full areas are collected using laser altimetry (from aeroplanes using laser technology). These data are adequate to answer questions about sand volumes. These data are available from the General Altitude File (AHN2) and the flood defence managers have them at their disposal. The resolution in terms of the location and altitude is suitable for establishing sand volumes and is improving all the time. GIS is needed to calculate volumes on the basis of the data. Maps are drawn up for specific areas that indicate how much sand has come in or been blown away annually. Comparing JARKUS sections can also provide information.

The water authorities have monitoring projects in place at a range of locations. Examples are:

Hoogheemraadschap Hollands Noorderkwartier:
- De Slufter on the island of Texel: the formation of new dunes in the mouth of the intertidal dune area;
- Castricum: the effect of the distance between permanent pavilions on dune growth and marram quality;
- Wijk aan Zee: the effect of a high pavilion on dune growth and marram quality.

Hoogheemraadschap Rijnland:
- Velsen/Bloemendaal: the impact of new channels excavated in the dunes on dune formation and drift to the area behind;
- Gouges near Noordwijk and Zandvoort and the Meijendel/Wassenaar blowout: ditto.

Waterschap Scheldestromen:
- Zeeuws-Vlaanderen: the development of parabolic dunes introduced in January 2011 as part of the Weak Links upgrade project;
- Zeeuws-Vlaanderen: the development of the Kruishoofd erosion bank introduced in January 2010 as part of the Weak Links upgrade project. The beach and the shore face are monitored in the context of the project, with the dunes being inspected visually only.

In addition, major sand nourishment operations are being monitored, as with Ameland and the Dune Compensation and the Sand Motor off the Delfland coast.

STOWA will be collaborating with water authorities locally on the monitoring of a number of areas. This information should provide an understanding of the impact that objects have on dune growth, the effects of blowouts on the backdune, and the capacity of dune slacks to match sea-level rise. At present, STOWA is looking at which monitoring approach is suitable for this purpose (airborne and/or satellite monitoring).

## 5.4 Intervention in response to undesirable developments

The reader is referred to the Digispection project that STOWA is working on with flood defence managers. This project supports the visual inspection of flood defences. Against that background, a Digiguide is being developed with pictures of damage to dikes and dunes: a guide that managers in the field can use to inspect the defences for which they have responsibility. At present, research is taking place to see how dynamic coastal management can be included in the guide using differentiation according to coastal type. The guide will also describe measures that managers can take to reverse an undesirable development.

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