Managing European Shorelines and Sharing Information on Nearshore Areas

messina

A Case Study Documenting Coastal Monitoring and Modelling Techniques in the Netherlands.

prepared in the framework of the MESSINA project

Isle of Wight Council

December 2005

Project part-financed by the European Union (European Regional Development Fund) within the INTERREG IIIC Programme

North East South West INTERREG IIIC

INTRODUCTION

The Netherlands lies on the northern coast of Europe and is situated between Belgium in the southwest and Germany in the northeast. The Netherlands boarders the North Sea which stretches from Cap Blanc Nez (France) to the north part of Jutland (Denmark) and is subdivided in three sections: the Delta coast, the Holland coast and the Wadden coast. The Holland coast forms the middle section of the Dutch coast and consists of a closed coast dune areas, varying in width from less than one hundred metres to several kilometres (*Eurosion, 2003).*

The Dutch coast is low-lying and thus extremely vulnerable to flooding and the potential risks of rising sea levels as a result of climate change. With 60% of the population living in low-lying areas and with 65% of the Gross National Product generated in coastal areas it is vital that coast protection and management are high on the national agenda.

On the 1st January 1990, the Dutch Government introduced a national policy to 'hold the line' in coastal areas in order to protect this low-lying land. Much of the Holland coast serves a key economic function, encompassing tourism, port industries, bulb growing, water abstraction activities and fisheries. Behind the dunes lies the political (The Hague) and economical centre (Amsterdam and Rotterdam) of The Netherlands. Where possible soft engineering in the form of beach nourishment or beach recycling is used although in many cases, harder alternatives have been required.

The Government is currently making plans for long-term coastal monitoring and management alternatives through a policy of Integrated Coastal Zone Management (ICZM) but, with much of the general public unaware of the dangers they face as a result of coastal erosion and sea-level rise, the main priority is to educate and inform the nation. In the past, many coastal management initiatives have lacked the vision for the longer term and have concentrated on current and near-future threats. It is hoped by increasing awareness between stakeholders and the general public that a more holistic and long-term approach can be adopted.

1. GEOGRAPHICAL OUTLINE

The Netherlands forms part of Western Europe, bordering the North Sea, between Belgium and Germany (Figure 1).

Figure 1. Location map of The Netherlands (http://www.phpclasses.org, 2005)

The Dutch coastline is formed primarily of sandy deposits as a result of the coastal and deltaic interplay between the North Sea and the rivers Rhine, Meuse and Scheldt. Successive fluctuations in climate change and sea levels since the last ice age (transgressive and regressive phases) have greatly influenced this formation and have resulted in the formation of a closed coast with dunes and sandy, multi-barred beaches (*Heij and Roode, 2003)*.

The coastline is characterised as a wave-dominated coast and has been subdivided into three parts based on differences in morphological appearances and the dominance of related physical processes (Figure 2):

- The Delta coast – a delta/estuary coast in the south-western part of The Netherlands. The Delta coast consists of a number of former islands, separated by tidal basins, inlets and an estuary. After the major flood disaster of 1953 most of the tidal basins were closed or semi-closed by large constructional works (the Delta works).

- The Holland coast - an uninterrupted coastline in the central part of The Netherlands between the Hook of Holland (south) and Den Helder (north), with city areas close to the sea.

- The Wadden coast - a barrier island coast in the northern part of The Netherlands. The Wadden coast consists of barrier islands alternating with tidal inlets and their related ebb-tidal deltas at the seaward side. The lagoon area (the Wadden sea) between the barrier islands and the mainland consists of several connected tidal basins with extensive tidal flats. (*Van Rijn et al., 2002*).

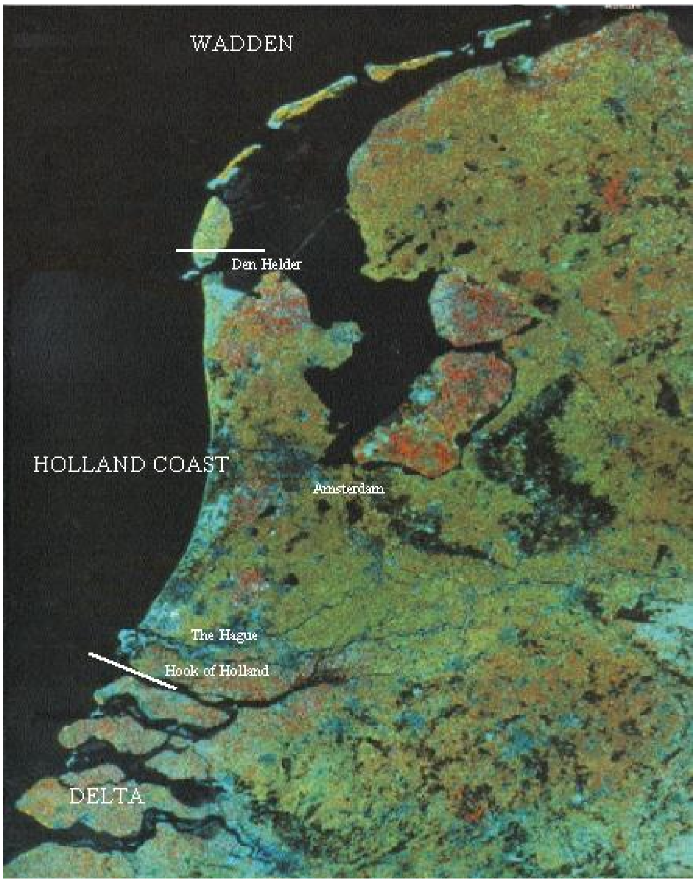

Figure 2: The three sections of the Dutch coast (*Heij and Roode, 2003 Eurosion Report)*.

The geology of The Netherlands coastline offers a natural sandy defence to the sea yet is highly vulnerable to marine and fluvial flooding. The greater part of the country is low-lying and does not rise more than 30 m/100 ft above sea level. Substantial portions of the provinces of North and South Holland, the offshore islands in the mouth of the Scheldt, and the West Frisian Islands are near, or below, sea level but have been reclaimed from the sea over the centuries (http://www.bbc.co.uk/weather/world/countryguides) (Figure 3).

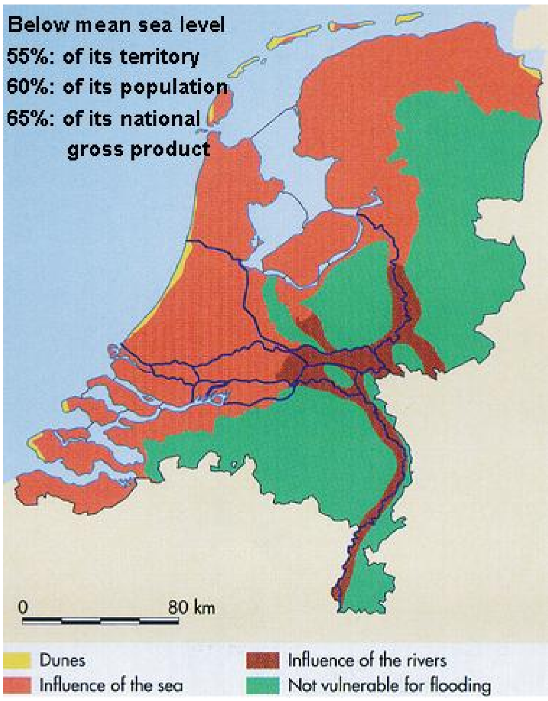

Figure 3: The percentage of The Netherlands below mean sea level (*Heij and Roode, 2003 Eurosion Report)*.

The risk of sea-level rise as a result of climate change has placed an ever-increasing threat on the Netherlands coastline and, as such, the policy for the coast is dominated by safety demands. Coastal squeeze, where the coastal margin is squeezed between the fixed landward boundary (artificial or otherwise) and the rising sea level has occurred in The Netherlands as a result of both the intensification of economic and social demands on the landward boundary and sea level rise. In 2000 the national policy for the coast became one of Integrated Coastal Zone Management (ICZM) where the focus was placed on sustainable spatial quality, while maintaining safety (Roelse, P. 2002).

A significant component of ICZM, alongside other issues including coastal planning, coastal engineering and environmental protection and enhancement, is maintaining the quality of the built environment of the coastal zone. As 60% of the population of The Netherlands live below the mean sea level and a large proportion of the country's economy is tourism-based clearly this is an issue in which the government must address. Furthermore, by 2006 the government must put in place its response to the EU Recommendation on ICZM, which requires a national strategy to be in place for delivering effective coastal zone management.

2. COASTAL MONITORING AND MODELLING TECNIQUES

2.1 COASTAL DEFENCE

Since the 16th century much of the low-lying Dutch Coast has been reclaimed for residential and industrial purposes. By the 19th century, with advancements in drainage techniques, it became possible to reclaim large areas of land by using steam driven pumping stations to drain large polders. Due to this expansion in the coastal zone in social and economic demands, the majority of the coastline has, in one form or another, been protected from the threatening seawater.

In the past, much of the coast was protected by man-made, hard engineering structures like dikes and dams. It was hope that these would provide a barrier to the encroaching sea and prevent flooding in the low-lying polders. However, it was soon realised that erosion was destroying these defences along with the majority of the Netherlands coast and so a softer engineering option was introduced whereby structures were built that worked with the natural depositional processes occurring at the coast. Goynes, known as a ‘strandhoofden’, and breakwaters were seen as the preferred option to build up beach and dune levels in order to offer a natural barrier to the sea. A policy of managed retreat, whereby nature is left to take its course to a large extent, was adopted around much of the remaining coastline of the Netherlands.

In 1990 Parliament adopted the envisaged policy of the Dutch government to stop further structural coastal recession. The Ministry of Transport, Public Works and Water Management established the ‘basal coastline’ as the position of the coastline on 1st January 1990 and determined that the coastline should be prevented from moving inland. The coastal policy of 1990 is referred to as ‘dynamic conservation’ and three goals were formulated (*Heij and Roode, 2003 Eurosion Report)*:

- No further retreat of the coastline
- Preservation of valuable dune areas
- Preservation of the natural dynamic character of the coast.

To reach these goals, a number of instruments are available (taken from *Heij and Roode, 2003 Eurosion Report)*:

- The annual coastal measurements and the acquired knowledge of coastal processes
- The basal coastline and annual assessment
- The technique of sand nourishment (beach nourishment and submerged nourishment). This technique can be described as *soft were possible and hard were necessary*. It is effective to stop erosion, flexible, not expensive and the best way to preserve the valuable dune areas and the natural dynamic character of the coastline.
- An annual budget for coastline management of € 40 million, which is 12 million m^3 of sand per year.
- Co-operation between Central Government, the coastal water boards, and Provincial Authorities/Consultative Bodies for the Coast (POK's). Responsibilities are divided as follow:
    - Central Government safeguards the position of the coastline and combats structural erosion
    - The coastal water boards maintain the sea defences
    - Provincial Authorities are responsible for overall co-ordination and integration with other areas of policy such as physical planning

Every year the position of the coastline is measured and compared with the reference standard. If it looks as if the basal coastline will be breached by ongoing coastal erosion, preventive measures are taken in advance. In practice, this means that sand nourishment is carried out. The result of the annual measurements is used as a basis for the annual sand nourishment programme. In this way, dynamic preservation is put into practice.

Since sand nourishment was adopted in The Netherlands coastal erosion has been almost entirely prevented. In 1990 30% of the coast was landward of the 'basic coastline'. In 2000 this was reduced to 10%. Because some natural fluctuations are acceptable as long as safety is not at stake, this 10% can be regarded as the maximal result (Figure 4) (*Heij and Roode, 2003 Eurosion Report*).

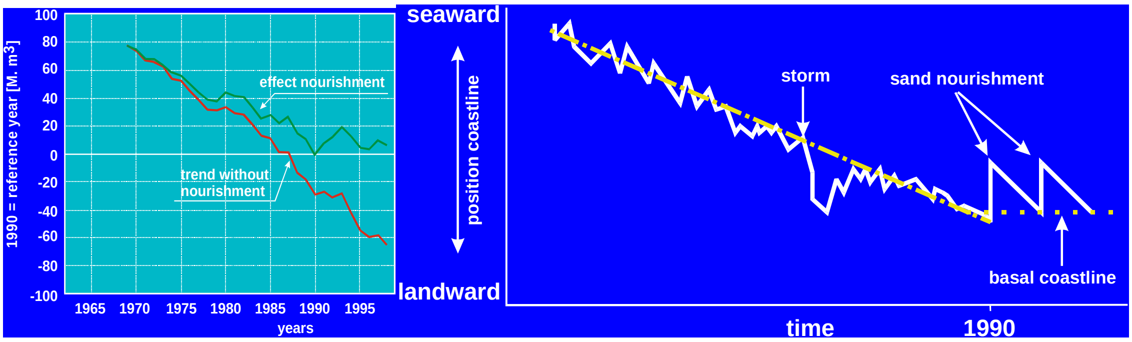

Figure 4: The effects of sand nourishment on the Netherlands Coast (*Ministry of Transport, Public Works and Water Management (V&W), 1996).*

2.2 TECHNICAL MEASURES

The Dutch coastline has been monitored for over a hundred years in order to establish the nature of change in the coastal morphology. Since 1967, an annual monitoring programme has been put in place where beach profile data is collected at intervals of 200 to 250 metres perpendicular to the coast. The results of these annual coastal measurements (known as JARKUS measurements) are stored in the Ministry's DONAR database (national database).

The 'wet' part of the profile is recorded by the Ministry's Survey Department or by water boards, using an automatic sounding system in combination with a computer used location system such as Geographical Positioning System (GPS). The 'dry' part of the profile is determined by using stereo photogrammetry. In the spring, the entire coastal strip is photographed from the air, each photograph overlapping the other by 60 %. These photos allow the height of the topographical surface to be determined in 3D using precise spot height data as reference points. Since 1994 height measurements of the beach and the foredune have been taken using a laser scanner on board an aircraft. The laser scans a given area and the distance from ground to aircraft is measured many times a second. Analysis of the results produces a Digital Elevation Model (DEM) from which the height at the location of the reference sections can be determined. When height and depth data are combined, the end result for each section is known as the JARKUS profile (V&W, 1996).

In the framework of the Coast3D Project a measurement campaign was conducted at Egmond, The Netherlands, during the spring of 1998. The Coast3D project is part of the European Commission's Marine Science and Technology Research Program (MaST-III). Within the Coast3D project (Coastal Study of Three-Dimensional Sand Transport Processes and Morphodynamics) field experiments at two locations were carried out, in Egmond (The Netherlands) and in Teignmouth (UK). The Egmond site can be considered as a coastal stretch where in alongshore direction relatively uniform hydraulic and morphological conditions prevail, while the British site is typically a 3D site (*E.P.L. Elias et a, 2000*).

The main objectives of the study were as follows:

- To improve understanding of the physics of coastal sand transport and morphodynamics.
- To remedy the present lack of validation data of sand transport and morphology suitable for testing numerical models of coastal processes at two contrasting sites.
- To test a representative example of numerical models for predicting coastal sand transport and morphodynamics against this data.
- To deliver validated modelling tools, and methodologies for their use, in a form suitable for coastal zone management.

Data from the experiment included water levels, wave height and period, wave speed and direction, sediment concentration transport, bathymetric surveys, tracer movements, and meteorological parameters.

The data from the experiments at both sites allowed comprehensive tests to be made of hydrodynamic and morphodynamic numerical models (*Soulsby, R. 2001*). Five different Coastal Profile models were used by the COAST3D modelling partners to stimulate the hydrodynamics and morphodynamics of the beach at Egmond. The results indicated a reasonably high quality of model performance especially in relation to profile models simulating wave height, longshore and cross-shore currents and hydrodynamics. Coastal Area Models proved successful in predicting tidal flows and morphological changes. It is hoped that with a better understanding of the processes involved from the data collected at the two sites, further developments in the numerical models can be made so that there can be direct uses for coastal zone management.

In the Netherlands coastal defence actions are merely based on sand nourishments. The sand nourishment method has been chosen because it is a relatively cheap method and because it interacts with the natural characters of the Dutch coast (*Heij and Roode, 2003 Eurosion Report*). The technique is a flexible, soft engineering approach towards combating coastal recession of the ‘basic coastline’. The sand is extracted from outlying sea bottoms of depths greater than 20 meters in order to minimize disruption of life on the sea bottom and to ensure that the coast is not undermined. With suction-hopper-dredgers the sand is brought to the coast where pipeline connections make the nourishment possible (NORCOAST, 1999).

Since 1990, the basic coastline has been maintained using sand replenishment, preventing the structural erosion of the dunes. However, this form of maintaining the basic coastline cannot prevent incidental erosion, which occurs during extreme storms. Sand replenishments are also not entirely successful in slowing the movement of erosion lines inland as a result of rising sea levels. It is therefore necessary to have other methods of coastal defence and management in place should the need arise for further protection. As with the basic coastline, there are three options for addressing the situation: keeping pace with sea level changes by maintaining the current basic coastline, moving inland by letting nature take its course, and moving the basic coastline offshore by building artificial sandbanks or defence structures. In 1990, the decision was taken to keep pace with sea level changes by defining a basic coastline and this policy has been maintained ever since (*Heij and Roode, 2003 Eurosion Report*).

CONCLUSIONS

Coastal defence and coastal monitoring in The Netherlands is primarily based on soft engineering, in particular, sand nourishment. Since 1990 a new coastal policy (dynamic preservation of the coast) was introduced in which sand nourishment was, and still is, the major means of controlling coastal erosion. No structural erosion is allowed (the coastline of 1990 is the basal coastline which must be maintained), but the coastal area is to remain as natural and dynamic possible. An evaluation of this coastal defence policy shows that coastal retreat can be stopped with sand nourishment. However, the realisation of the serious threat of sea-level rise and increased storm frequency as a result of climate change has encouraged new thinking on possible methods of maintaining the basic coastline. Developments in monitoring and modelling techniques as a result of the COAST3D programme will hopefully provide new answers on best practice in the coastal zone. The recent move towards Integrated Coastal Zone Management following the EU Demonstration Programme and publication of "Integrated Coastal Zone Management: A Strategy for Europe" in 2000, has encouraged a more holistic approach to coastal management taking into account physical, socioeconomic, and political interconnections both within and among the dynamic coastal system.

REFERENCES

Richard Soulsby HR Wallingford

COAST3D, 2001. COAST3D Final Volume of Summary Papers. Report TR121, HR Wallingford, UK