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Coastal state indicators to assess the morphological development of the Holland coast due to natural and anthropogenic pressure factors

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ABSTRACT

The description of the state and possible changes of a physical system, through an objective, simple and standard methodology is becoming a daily requirement for coastal managers. The implementation of national and international regulations is in fact nearly fully based on the use of such indicators. On the other hand, scientists spend a considerable effort into trying to express and understand the physical processes underlying a certain system, but often they do not put the necessary effort to translate them into useful indicators which can be used by coastal managers. This paper tries to close the existing gap between scientists and coastal managers by describing the morphological development of the Holland coast through an indicator approach. In particular, three indicators have been chosen to quantify three different coastal functions, i.e. the short-term safety, the medium term safety and the available space for nature and recreation. The dynamics of the indicators have been quantified in relation to the external pressure factors determining those changes. Those relations provide simple rules of thumb which can be used by coastal managers to quantify the effects of specific actions (e.g. implementation of nourishments), to assess the impact of changes in the natural forcing (e.g due to climate change), or as a basis for cost-benefit analysis.

1. Introduction

Coastal state indicators have been widely used in recent years in different disciplines related to oceanography, marine ecology, biology and coastal engineering. Coastal managers supported by scientists feel an increasing pressure from national and international authorities to define those indicators. For example, the European Water Framework Directive (Directive, 2000/60/EC) and the most recent European Marine Strategy Framework Directive (Directive, 2008/56/EC) are based on the definition of Good Environmental Status, completely described by a number of targets and indicators. Indicators are used to monitor environmental issues and, as management tools, to assess the effectiveness of policies, by measuring the progresses towards a certain target.

On the other hand, the information provided by scientists is often too complicated and the communication between scientists and coastal managers very ineffective (Van Koningsveld et al., 2005; Ojeda-Martínez et al., 2009). The scientific community is mainly working on very detailed aspects of one specific problem, while managers are interested in the holistic view, with a lower degree of detail, of the entire physical system. Stojanovic et al. (2009) suggested that 'communication' between scientists and stakeholders should be preferred to 'dissemination', involving a two-way transfer of information and they indicated as an example to reach this objective the set-up of 'coastal partnerships'.

Considerable efforts to improve this situation has been made for example in the CoastView European project (Davidson et al., 2007). Video-derived coastal state indicators have been applied for monitoring the coastline evolution (Kroon et al., 2007), the level of beach-use and the beach safety (Jiménez et al., 2007).

The present investigation aims at describing and quantifying the morphological development of the Holland coast through an indicator approach, in a way that can support coastal managers. At first, the main natural and anthropogenic external pressure factors are depicted. This is followed by choosing three indicators to quantify possible changes to three different coastal functions represented by the short-term safety, the medium term safety and the available

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space for nature and recreation respectively. Relations between external pressure factors and morphological indicators have been derived. Moreover, possible relations between different indicators have been investigated. Those relations are useful because they can help coastal managers in optimizing their effort, and achieving multiple goals by intervening on one indicator only.

2. Study area

2.1. Geomorphological setting

The Holland coast is located in the central part of The Netherlands. This stretch of coastline has a length of approximately 120 km, and it is bounded in the North by a tidal inlet named the Marsdiep, connecting the Wadden Sea to the North Sea, and in the South by the jetties of Hoek van Holland, allowing the access of ships to the harbour of Rotterdam. The coastline has a slightly concave plane shape, with an orientation increasing from 2° with respect to the North in the northern part, and up to about 40° in the South (Fig. 1).

Most of the present coastline is characterized by sandy beaches running sub-parallel to a sandy dune system, which protects the inner areas from flooding, and which has an important ecological value (Fig. 2). Hard structures i.e. jetties, seawalls, groins are also present but, whenever possible, they have been recently covered by sand, making the coastline more attractive for tourists and more natural. The beach has a slope on average between 1:35 to 1:60. Periodical onshore and offshore migration of the coastline is related to the passage of sand waves. The surf zone is mainly characterized by a breaker bar system with typically 2-3 breaker bars. The average grain size ranges approximately between 200 and 300 μm.

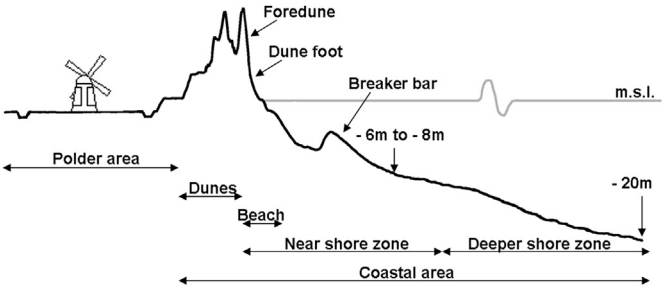

Fig. 2. Typical cross-shore profile of the Holland coast.

2.2. Natural forcing

2.2.1. Short- and medium-term morphological development

The Holland coast is a microtidal, wave-dominated coast. The tidal range along the coast varies between 1.4 m near Den Helder to 1.7 m near Hoek van Holland. Tidal currents are asymmetric with a peak in northward-directed flood currents at spring tide of about 0.8 m/s and a peak in southern-directed ebb currents of about 0.7 m/s.

The wave climate is dominated by waves coming from the northwest (North Sea) and from the southwest (English Channel). A seasonal pattern can be identified, with a monthly average offshore wave height of about 1.7 m during the winter months and of about 1 m during the summer months (Wijnberg, 2002).

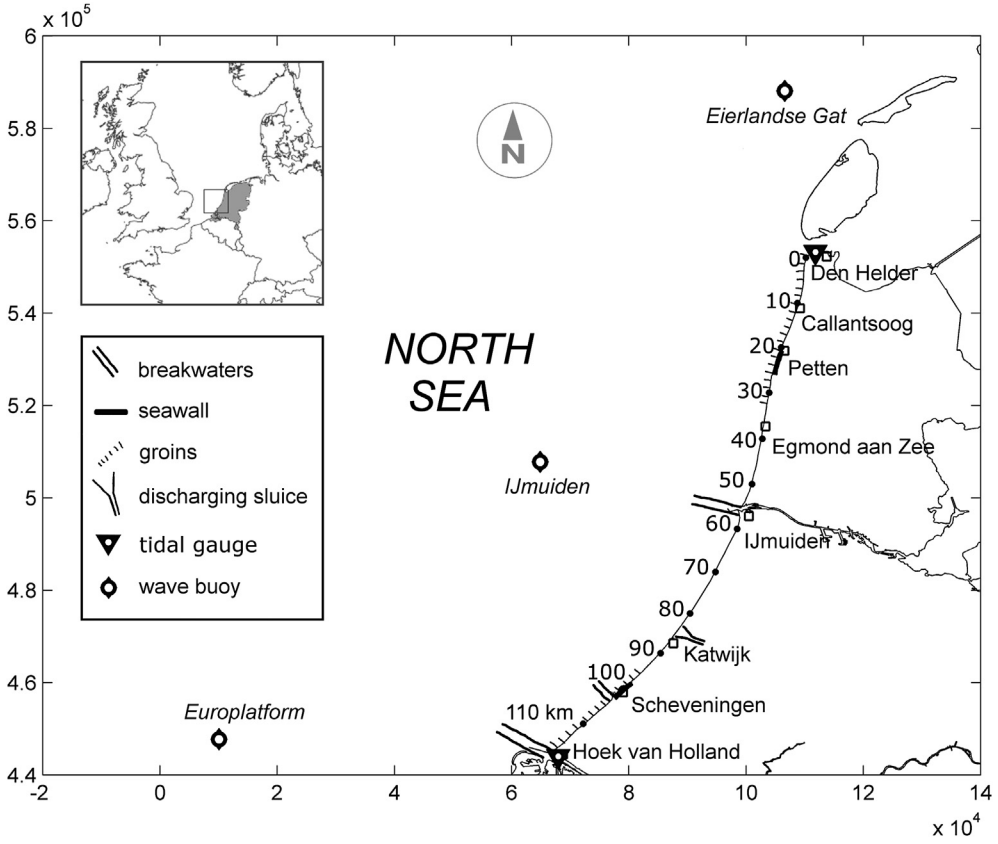

Fig. 1. Map of the Holland coast. The main hard structures are also indicated, as well as the locations of the tidal gauges and wave buoys used within the study.