LONG-TERM AUTONOMOUS MORPHOLOGICAL TRENDS OF THE BELGIAN SHORE

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Bathymetric and aerial topographic surveys spanning 2 to 3 decades of morphological evolution have been processed into volume time series for the 254 sections covering the Belgian shore (fig. 1). During these decades, numerous human operations, involving the supply of millions of cubic metres of sand in order to maintain the resort beaches and the coastal safety level, have been conducted.

An analysis of these long-term trends is necessary for various reasons: (a) evaluation of the effect of nourishment (e.g. quantification of possible acceleration of erosion trends), (b) evaluation of hard structures like groins, (c) estimating the total longshore sediment transport and (d) the calibration and validation of numerical morphological models.

The amounts involved were backstripped from the volume evolution time series in order to obtain corrected trends per coastal tract (group of sections with a length of about 1km, showing a similar morphological evolution). The corrected time series can be considered to better reflect the autonomous morphological evolution, i.e. what would occur in the absence of human interventions. The trends were determined by linear regression of volumes per metre coastal length over homogeneous trend periods. The significance of the trend is expressed by the regression coefficient. Separate trends were computed for the "below low-water" part (shoreface and seabed in an about 1.2km wide nearshore area) and the about 0.3km wide beach (foreshore, backshore and dune front) (fig. 2). The analysis of the trend figures per section and section tract was supplemented by the patterns of morphological change revealed by successive height difference maps and contour line shifts (fig. 3) through time.

The volume trends of the beach on the one hand, and the nearshore area on the other hand, are both mostly within the range of -20 to +20$m^3.m^{-1}.yr^{-1}$. A slight predominance of accretion near the French border (updrift with respect to the longshore sediment transport) gradually shifting to mild erosion near the Dutch border (downdrift) is an overall characteristic of the recent morphological evolution of the Belgian shore. Superposed on this general observation, stronger trends are often related to morphological adaptations near important structures.

In Koksijde, a decade of beach and shoreface growth was observed after the construction of two long groins in 1986-1988. Accretion continues at a lower rate up to now. The groins may also have induced a slight seaward shift of a local nearshore flow channel.

Over the 22 km long shoreline tract from Nieuwpoort to Bredene, the 6 to 7 m deep (below LLW) longshore channel "Kleine Rede" tends to shift landwards causing erosion at the shoreface toe. The correlative erosion observed at the beach is countered by yearly small-scale and local large-scale sand nourishments. Redistribution by natural processes of the sand volumes trucked and pumped in effectively compensates the shoreface toe erosion, so that the longer-term evolution of the channel is stable and even some shallowing by 0.25m is observed over the last decade. Locally, off Westende, shallowing by over 0.5m is related to dumping of dredged sand from Nieuwpoort harbour entrance.

A recent channel bed shallowing occurred off Oostende centre after 2004: a relatively large net import from the beach nourished there in 2004 and kept since then by maintenance nourishments, is suspected. The corrected trend of Oostende beach since 2004 is -42$m^3.m^{-1}.yr^{-1}$ and is at present the strongest erosive trend observed at the Belgian coast.

The beaches around De Haan suffered strong and repeated storm erosion in 1989-1993. A rather abrupt scouring of the longshore flow channels was observed here in 1988-1993. This seems to have been a natural process that may constitute one explaining factor of the strong beach erosion observed then in the area. Important nourishment works with coarser sand have been carried out in response in 1990-1997, including the construction of a submerged "feeder berm". After this, the beach and shoreface in the area appear to be in a state of equilibrium, with the eastern part of the nourishment area even showing beach growth of around +10$m^3.m^{-1}.yr^{-1}$. The last years showed an eastward shift of the shallow seabed area separating the nearshore channels "Kleine Rede" and "Grote Rede" east of Bredene. There may be a relation to the Oostende harbour works going on (new harbour channel dredged and new dams under construction), but a direct link could not be shown and therefore, the shift appears to be a natural phenomenon.

Wenduine occupies a cape position of the Belgian shore. The longshore flood channel "Grote Rede" shows a trend of deepening in this area. After the De Haan nourishments, that trend was temporarily reversed, but it resumed since about 2000. Some parts of the channel bed are now 0.5m deeper than in 2000, while the shoreface toe shows local deepening between 0.5 and 1m since 2000. The significantly erosive corrected trend of Wenduine beach of -27$m^3.m^{-1}.yr^{-1}$ is thought to be related to this offshore evolution.

Further east, a part of Blankenberge beach suffers a mean yearly erosion of -31$m^3.m^{-1}.yr^{-1}$. Here, the maintenance dredging works in Blankenberge harbour entrance area may explain the erosion, as these works deplete the beach of the longshore littoral drift transport.

A few kilometres on to the east, Zeebrugge's outer harbour dams block virtually all of the littoral drift. Since their completion in 1979, linear accretion is observed at the beach west of the dams. The accretion zone is gradually extending more westward and now approaches Blankenberge. Beach accretion rates are over 65$m^3.m^{-1}.yr^{-1}$ near Zeebrugge and increase from 10 to 30$m^3.m^{-1}.yr^{-1}$ between Blankenberge and Zeebrugge. Also the nearshore area here shows important accretion, though rates have dropped from over 60$m^3.m^{-1}.yr^{-1}$ to below 50$m^3.m^{-1}.yr^{-1}$ since 2007. Possibly, the nearshore morphology is approaching a new equilibrium state adapted to the harbour configuration.

The beach immediately east of Zeebrugge is depleted from the littoral drift. Its corrected volume trend is -23$m^3.m^{-1}.yr^{-1}$. Further eastward, at the protruding parts of the beaches of Knokke, where several replenishments were necessary, rates of erosion reached values of -40$m^3.m^{-1}.yr^{-1}$, but the corrected trend has dropped to about -15$m^3.m^{-1}.yr^{-1}$ since 1991. Nearshore accretion areas, related to morphological adaptation around Zeebrugge outer harbour also at its east side, are extending gradually eastward and recently impinge on the ebb channel "Appelzak". This may be one reason for the milder recent beach erosion figures at Knokke-Zoute.

The above description is necessarily succinct. The results of the analysis presented here are described in full detail and with the necessary background data in a report in Dutch, "Morfologische trend van de Vlaamse kust in 2011" (Rik Houthuys, 2012), available on demand at kust@vlaanderen.be.

Fig. 1. Map of the Belgian shore with names cited in the text.

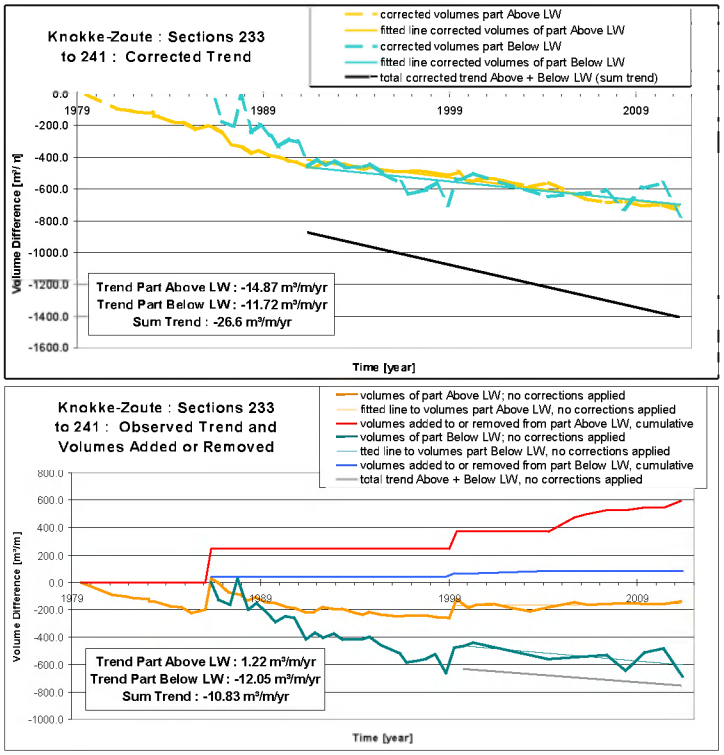

Fig. 2. Example of volume graphs for the tract at Knokke from section 233 to 241.

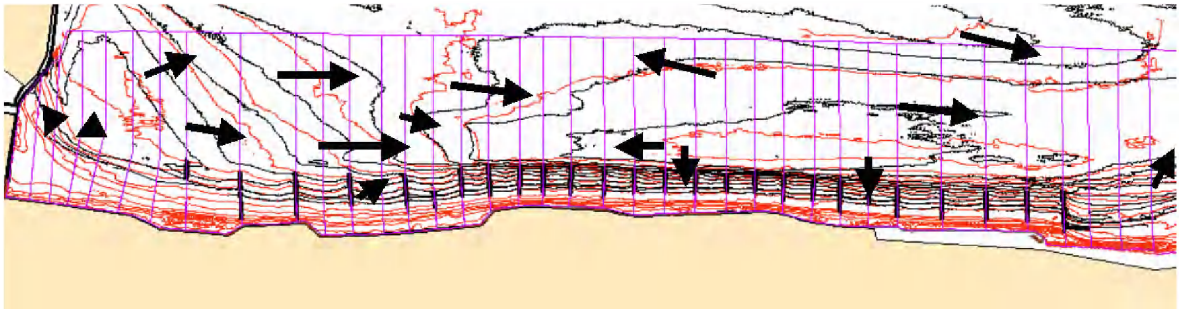

Fig. 3. Map showing 1997 (red) and 2011 (black) height contours, with 1 m interval. Black arrows indicate sense of growth or displacement of morphological features (they do not represent sediment transport paths). Area shown is the ca. 10 km long part of the Belgian shore between Zeebrugge (left) and the Dutch border (right). Mainland is below and seawall and groins are indicated.