# Littoral Drift Barriers and the Problem of Proving Accelerated Recession

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**Abstract**

Any barrier to longshore drift has the potential to cause downdrift erosion. Understanding this problem means that any new construction of a groyne field or breakwater should be accompanied by monitoring to record changes in beach volumes and profiles as well any erosion of the coastline. In the past, such care may not have happened, especially in those cases involving boundaries between authorities responsible for the coast, or where the ground liable to be eroded was not considered to be of high value. This paper proposes a way by which previous groyne construction, or other coastal works, may be deemed responsible for increasing the rate of soft cliff erosion beyond a value which could be ascribed to being the result of a natural variation in recession rate.

**Keywords**

Longshore drift • Marine erosion • Recession • Groyne • Breakwater

## 2.1 Introduction

A set-back in the line of an undefended cliffed coast with respect to an updrift defended coast is a very common coastal feature (Fig. 2.1), ranging from tens to hundreds of metres in length. Where an undefended coast has previously had a large littoral drift volume of beach material and a new littoral drift barrier, such as a breakwater or groyne field, it acts as a barrier leading to a reduction in sediment downdrift. Naturally it is held responsible for the recession of the downdrift coast. Numerous examples of this have occurred on previously undeveloped coastlines (Anderson et al. 1983 and Komar 1983). An example of where doubt cannot exist is provided by the Orissa coast of India (Mohanty et al. 2012) where two groynes are protecting a harbour mouth: much accumulation is taking place updrift of one groyne and severe erosion taking place downdrift of the other. The erosion is clearly at the expense of the material being held up on the updrift side of the harbour.

By contrast, where the coastline has had a long history of development, with coastal defences constructed at various times and much interference with beach volumes, locally or within the sediment cell, it becomes problematic as to the extent to which observed downdrift erosion can be ascribed to the influence of any new coastal defence works. The purpose of this paper is to examine how we may be able to assess whether or not new, or recently extended coastal defences are responsible for an acceleration in the downdrift rate of recession.

## 2.2 Reasons for Proving Accelerated Recession

Our reasons for evaluating the extent to which new defence works are the principal cause of accelerated recession may be (i) for legal reasons where the liability for land loss is under investigation (Maddrell and Gowan 2001), (ii) planning and coastal management, especially in respect of the design of new works, (iii) determination of future land values and (iv) as a guide to the growth of the defended

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coast as an artificial headland and subsequent growth of an embayment downdrift. For all of these purposes, it will be necessary to take into account all of the factors which influence the rate of erosion and hence the recession of the coastline. These factors can be listed in terms of their time of operation as follows:

- **Historical**—hard and soft constructive activities up and downdrift, beach mining (particularly for sand and gravel) and the time lapse needed for the restoration of equilibrium following the updrift changes.
- **Present**—the periodicity of cliff movements, changes in geology as recession proceeds, the delayed response of clay cliffs to past toe erosion, groundwater fluctuations and the incidence of storm conditions.
- **Long Term**—wave climate and offshore bathymetric changes, sea-level rise and other responses to climate change.

## 2.3 Methodology

The previous rate of recession will be obtained from Ordnance Survey maps, aerial photographs, traditional ground surveying and modern differential GPS surveys. Recession is calculated with respect to the cliff edge which acts as the clearest and most unequivocal feature of the coastline. The error range will come from a combination of surveying and reading errors, the deformation of historical maps and unrectifiable photographic errors following survey practice and literature. The objective is to compare the observed recession since the date of construction ($R_{observed}$) with the recession that would have been obtained had the preceding recession rate continued in the absence of the sea defence works: the "maintained" value ($R_{maintained}$). Where the observed recession, allowing for the error range ($\pm E$), is clearly greater than the maintained recession, also allowing for the errors, then we can refer to the difference as the "excess" recession ($R_{excess}$) as follows:

$$R_{excess} = [R_{observed}(\pm E)] > [R_{maintained}(\pm E)] \quad (2.1)$$

The value of the maintained recession is taken from a sufficiently long time period leading up to, and not after, the construction commenced. It is important that the maintained value covers a time period sufficiently long to obtain a full representation of all the "current" factors influencing the rate of erosion as listed above. The historical factors should be excluded unless there are reasons to consider they may still be active and likewise the long term factors can be also be excluded where over the time period selected, their influence is very small. The exact length of the time period will depend on the dates of available data and its consistency but short periods are liable to be overly reflective of infrequent events. From studies of various soft cliff localities in the UK, it has been observed that a reliable time period is approximately 30–50 years (Brown 2008). It is appreciated that despite a thorough check of causes of past retreat rates, these retreat rates may not continue in the future, but without detailed, costly modelling, it is the most simple, quick and best available method.


**Fig. 2.1** Aerial view of the set-back downdrift of the defence works at Hornsea on the Holderness coast of Yorkshire, UK, where a 1,544 m groyne field was extended by 290 m (including a small shore parallel extension). The *inset* map shows the location of the Holderness coast (Photograph from Google Maps)

## 2.4 Applications at Holderness

### 2.4.1 Hornsea

Following the original piecemeal construction along 1,544 m of coast at Hornsea over the period 1906–1954, there is a clear excess retreat over what would have been the maintained rate of recession. However the extension of the groyne field by 290 m as shown in Fig. 2.1, completed in 1977, does not give an excess over the maintained value for a measurement period of 37 years. It appears probable that the retreat being experienced from the original construction was still influencing the downdrift coast and the small extension shown was not sufficient to make a major impact (Brown et al. 2012).

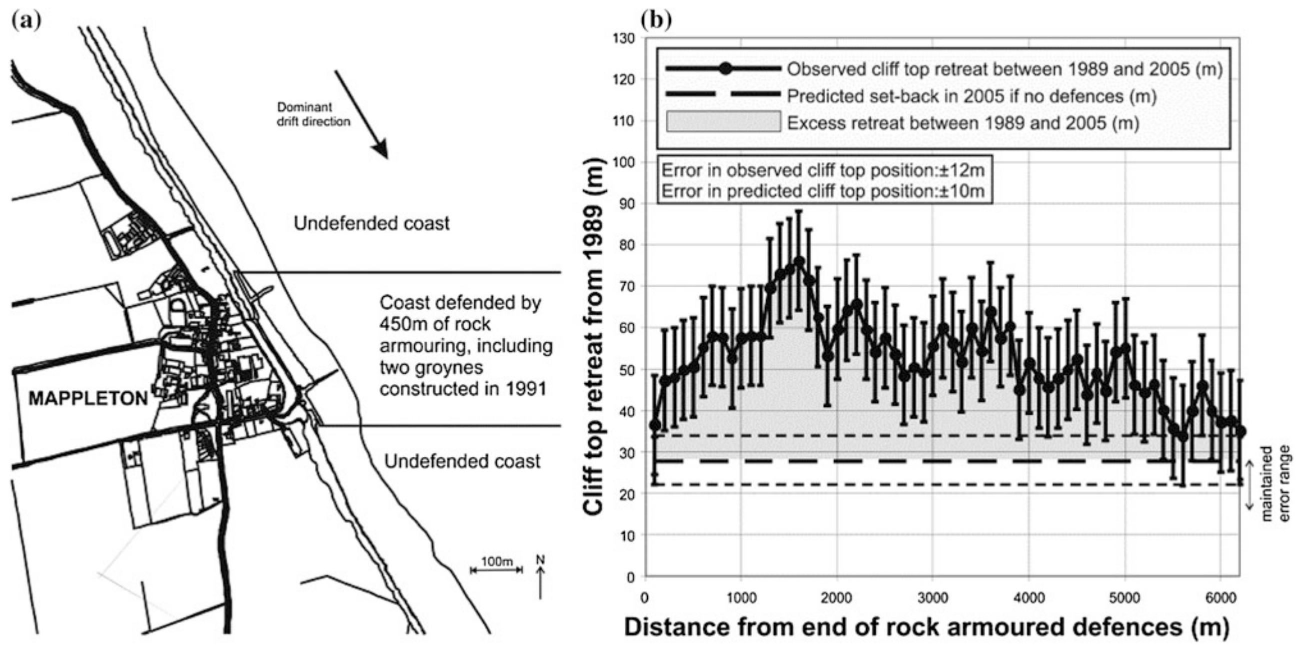


**Fig. 2.2** **a** and **b** Mappleton defences and set-back down-drift of defence to illustrate excess retreat to 2005, if the maintained rate had continued after 1989

### 2.4.2 Mappleton

The village of Mappleton located 3.1 km downdrift of Hornsea provides a clear example where excess retreat, as defined by Eq. 2.1, has taken place. Before protection, the coastline was subject to parallel retreat. In 1991, 450 m of shore parallel rock armouring and two rock groynes were constructed (Fig. 2.2a), creating a set-back down-drift. Retreat rates downdrift increased from 1.7 ± 0.6 m/year (1952–1989) to 3.3 ± 0.8 m/year (1989–2005) after defence construction. Assuming the retreat rate from 1952–1989 was maintained, this resulted in an average excess retreat of 25 ± 12 m up to 4 km downdrift (Fig. 2.2b).

The increased rate of erosion at Mappleton became the subject of a land tribunal from 1998–1999 (Lands Tribunal 1999) where the landowners requested compensation for the excessive land lost. The outcome was that the defences were not responsible for the 7 years of excess erosion examined. However, as discussed in Sect. 2.2, coastal retreat has a natural temporal variation and a much longer period than 7 years after construction is required for proper assessment of the influence of the defences. Our figures show that over a period of 14 years, it is clear that excess retreat had occurred. Ideally, the assessment should extend over a longer period to provide a full representation of all the factors influencing erosion but in practical terms this could aggravate the hardship suffered by an impoverished landowner seeking redress for the land loss.

## 2.5 Discussion and Conclusion

Various authors have discussed the temporal and spatial variation in rates of cliff erosion on the Holderness coast (Maddrell et al. 1999; Pethick 1996 and Quinn et al. 2009), a major factor of which is the variation in storm surge activity and periodicity of retreat due to geotechnical reasons. It is for this reason that an appropriately long length of time must be allowed for the assessment of recession in order to obtain an average which reflects this degree of natural variation. The high rate of erosion which occurred in the short period of 7 years in the case of the Mappleton inquiry, allowed the Tribunal to point to the high variability of shoreline erosion as a factor which overrode any effects due to downdrift erosion (Lands Tribunal 1999). The contribution which downdrift erosion due to the groyne construction made to the severity of the cliff erosion was effectively ignored. Depletion of beach material by the construction of barriers on a coast where there is a high rate of longshore drift and where the total beach volume is not adequately replaced by such cliff erosion is a common cause of serious shoreline retreat worldwide. This inevitable process cannot be ignored in the design of defence schemes. Indeed, in recent years set-backs have been seen as a feature of the protection works to create emerging stable embayments (e.g. Hsu et al. 2008).

During the 20th Century the influence of sea-level rise would have been minimal compared with the other factors that influenced coastal retreat. With climate change, sea-level rise this century is expected to be more than the last, thus changing the temporal variation in recession rate. Hence historical shoreline analysis to assess downdrift erosion may become less appropriate. However historical studies can be augmented with the full panoply of modern monitoring and modelling techniques now readily available (such as the system described by Mohanty et al. 2012) to evaluate sediment movement and rates of recession.

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