MARSDEN BAY

V.J. May

OS Grid Reference: NZ400650

Introduction

Marsden Bay (see Figure 7.1 for general location) includes beach, rock and cliff features and is a classic locality for beach process studies, based on the work of C.A.M. King over 50 years ago (King, 1953). Until very recently, it was the only site where the behaviour of beaches resting against relatively resistant cliffs had been studied intensively. King's analysis of the relationship between beach profiles and wave conditions influenced much subsequent work on beaches, and as a result, the location is frequently cited in the literature. It is also notable for a suite of cliffs and shore platforms cut into the Permian Magnesian Limestone, which crops out only on this part of the British coast between the River Tyne and the River Tees, and it contains the best examples of stack and cliff development in this rock type. The Permian concretionary limestone is most common in the headlands, stacks and arches, whereas the bays are cut into a weaker dolomite. An intricate assemblage of forms has developed as local small-scale joints have been exploited by marine erosion. Although Marsden Beach itself is dominated by sand with some shingle, there are also cobble and boulder accumulations associated with both the cliff-foot and former stacks. This site remains better documented than any of the other small cliff-foot beaches that occur along the north-east coast of England.

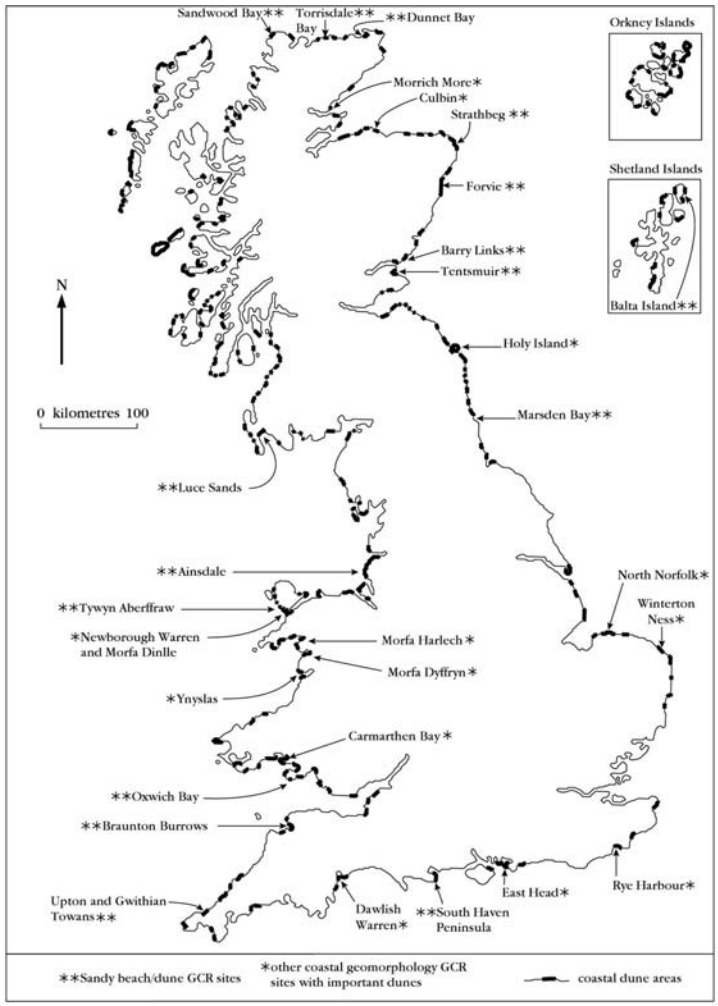

Figure 7.1: Great Britain sandy beaches and coastal dunes, also indicating the location of GCR machair-dune sites (see chapter 9) and other coastal geomorphology GCR sites that contain dunes in the assemblage.

Description

Marsden Bay is a small bay some 1200 m in length in the limestone cliffs between the rivers Tyne and Wear (see Figure 7.1 for general location). The site extends southwards beyond the bay itself to include parts of the cliffs towards Lizard Point (Figure7.2). At the northern and southern extremities of the site the cliffs are about 15 m in height, but rise behind the bay to between 25 and 30 m. High spring tides reach the foot of the cliff throughout the site. There are no other sand or shingle beaches close to the site, andKing (1953) suggests that it is unlikely that longshore transport carries any sediment into the bay. As a result, the only sources are the cliffs or the offshore zone; the cliffs themselves appear incapable of supplying the sand volume although they do supply limestone clasts. The beach faces north-east with a maximum fetch to the north of at least 1900 km. King chose the beach to compare the effect of the prevailing offshore south-westerly wind with that of the dominant onshore northerly wind.

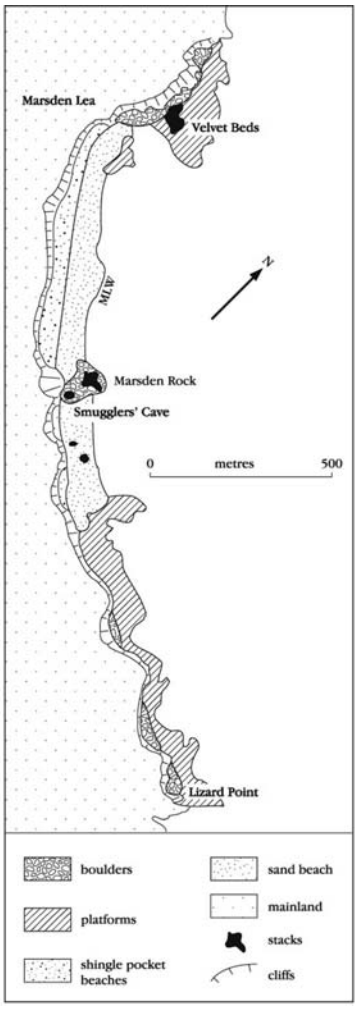

Figure 7.2: Key geomorphological features of Marsden Bay, Marsden Lea to Lizard Point.

The northern part of the site is dominated by cliffs much broken by caves, arches and a large stack. A platform cut in the limestone extends offshore for about 200 m and strongly refracts all waves approaching the cliffs. The foot of the cliff is littered by cobbles and boulders of limestone, their size and shape being strongly controlled by the blocky nature of the local rock. Marine quarrying and abrasion exploit the numerous small joints in the limestone. There are several stacks and stumps towards the centre of Marsden Bay (Figure7.3), which show evidence of being more strongly controlled by larger discontinuities. The two largest stacks have upper surfaces at 27 m and 24 m, i.e. about the same as the adjacent cliff top. In February 1996, the roof of the largest arch collapsed and Marsden Arch became a stack. The cliffs in the southern part of the site are more strongly controlled by the jointing pattern with

short straight sections separated by sharp almost right-angle joint-controlled bends. Cobbles and boulders have accumulated within the resulting small bays.

Figure 7.3: Marsden Bay – view looking towards the north-west showing the Magnesian Limestone cliffs and stacks and stumps. (Photo: V.J. May.)

King's 1953 paper describes the changes that occurred in the sandy beach profiles under certain well-defined conditions as follows.

1. Swell with an onshore wind produced long high waves. These were steep high-energy waves that proved very destructive, carrying sand seawards. Because these waves have a long period and are steep, the resultant beach was low and relatively wide.

2. Swell with an offshore wind produced long low waves. These flat waves are constructive, though with only moderate energy. Sand is moved landwards from the lower to the upper beach. The beach gradient remained low.

3. Local stormy sea with an onshore wind produced short high waves. These waves are very erosive, cutting into the upper beach and moving sand to the lower beach. Beach gradient is flat.

4. Locally generated waves with offshore winds produced short low waves. These waves are very flat and have little energy. Although they are constructive, the action is limited to a narrow zone, in which the beach gradient is steep as a result of the combination of both short period and flat waves.

King concluded that on Marsden Beach the prevailing offshore wind is associated with constructive wave action, and the dominant onshore wind with beach erosion.

Interpretation

King's 1953 paper was a significant step in the understanding of beach processes. Previously, most studies had concentrated upon spits and barrier beaches, such as those at Hurst Castle, Hampshire, and Scolt Head, Norfolk, and the behaviour of beaches that were free to transgress the land behind them. At Marsden Bay, the beach (composed of fairly coarse sand and gravel) rests against a cliff and so its long-term movements are controlled by the rate of retreat of the cliffs and the associated supply of sediment from them. Within those constraints short-term changes in beach profile are related to wave type and wind direction. Marsden Bay offers an

opportunity for assessment of the effects that future sea-level change may have on cliff-foot beaches. As sea level rises, the tidal duration curve on a cliff-foot beach should move up the beach slope. Since the beaches at Marsden Bay appear to have retained a similar volume since King's surveys, they provide an opportunity for use as a baseline for process-response studies as the rate of sea-level rise changes.

The second reason for the importance of this site is the development of the stacks and caves in limestone dominated by small, closely spaced joints. Although the southern part of the site is controlled by larger, more widely spaced, joints, there are few stacks there. Other sites with comparable forms (e.g. the GCR sites South Pembroke Cliffs, Flamborough Head, Kingsdown to Dover, Ballard Down) have major joints that control either or both cliff form and cave–arch–stack development. In relatively weaker materials such as the Chalk and the Keuper Sandstone (e.g. the GCR site Ladram Bay) the presence of a more resistant layer at the foot of the cliff appears to be especially important in increasing the likelihood that stacks will develop (Precheur, 1960). Since these conditions appear to be unimportant in Marsden Bay, other factors such as the local structure of the Magnesian Limestone, its strength, the role of boulders in modifying the behaviour of waves locally, and the nature of the intertidal platform may all play a part. Much of the platform, for example, is covered by small boulders derived from the Magnesian Limestone. Their dimensions are strongly related to the blockiness of the limestone. Their presence makes the platform surface particularly rough when compared with many of the Chalk platforms farther south (for example Flamborough Head, Joss Bay, Kingsdown to Dover), and so wave quarrying at most states of the tide is likely to be less effective than where blocks are absent. However, abrasion might be enhanced where blocks occur. Variations in jointing along the cliffs may give rise to differences in rock strength that in turn affect the development of bays and headlands in the site, and these deserve further investigation.

Conclusions

There are two key features of this site:

1. It provides a benchmark for beach studies both because of its suitability for surveys continuing King's work in the 1950s and because that work provided a frequently cited demonstration that wind and wave conditions affect beach behaviour on much shorter timescales than the seasonal beach models elsewhere.

2. It represents cliff–beach–platform development in a rock type that is little represented along the British (or European) coastline, and offers an additional example of forms such as stacks and arches.

Reference list

King, C.A.M. (1953) The relationship between wave incidence, wind direction and beach changes at Marsden Bay, County Durham. Transactions of the Institute of British Geographers, **19**, 13–23.

Precheur, P. (1960) Le Littoral de la Manche de Ste Adresse à Ault, SFIL, Poitiers, 138 pp.