Marine Geology 262 (2009) 82–95

Contents lists available at ScienceDirect

Marine Geology

journal homepage: www.elsevier.com/locate/margeo

Tide-driven dune migration and sediment transport on an intertidal shoal in a shallow estuary in Devon, UK

Gerd Masselink *, Laurie Cointre, Jon Williams, Roland Gehrels, Will Blake

School of Geography, University of Plymouth, United Kingdom

ARTICLE INFO

Article history:
Received 12 June 2008
Received in revised form 4 March 2009
Accepted 15 March 2009

Communicated by John T. Wells

Keywords:
Intertidal dunes
Bedforms
Bedload equations
Sediment transport
Estuarine evolution

ABSTRACT

The migration of subaqueous dunes was investigated over a 3-month period on an intertidal shoal near the mouth of the shallow mixed wave/tide dominated Avon Estuary on the Channel coast of southwest Britain. The dunes, characterised by heights and lengths of 0.05–0.2 m and 5–10 m, respectively, migrated 10–20 m over the 3-month period, representing an average volumetric sediment transport rate of 0.5 m^3 per unit meter width. Compared to equilibrium models of dune dimensions based on the water depth, the dune height was predicted well, but the dune length was under-predicted. Sediment transport on the intertidal shoal was controlled by a distinct tidal asymmetry, with maximum flow velocities during flood (0.4–0.5 m s^{-1}) significantly stronger than during ebb (0.2–0.3 m s^{-1}). Predicted bedload transport based on theory underestimates the actual transport and this is attributed to the modest flow velocities encountered and, perhaps, the importance of suspended load transport. However, when empirically calibrated and related to tide range, the transport equation adequately accounts for observed rates. Using nearby tidal observations, the predicted annual volumetric sediment transport rate is 2.6 m^3 per unit meter width. This estimate compares favourably with the annual volumetric sediment transport based on dune measurements (2.0 m^3). Using the notion that the transport rate decreases on the intertidal shoal in the up-estuary direction to zero at its up-estuary end, a vertical accretion of 0.5 cm yr^{-1} was predicted. The main implication of our study is that accurate and well-designed process measurements of dune dynamics and tidal currents can provide useful information on the longer term evolution of intertidal shoals in sandy, shallow (flood-dominant) estuaries.

© 2009 Elsevier B.V. All rights reserved.

1. Introduction

Subaqueous dunes are common features in estuarine environments and develop in fine-to-medium sand-sized sediments when flow velocities are 0.5–1 m s^{-1} (Ashley, 1990). They are of major importance in controlling estuarine sediment dynamics either indirectly, by presenting important bed roughness elements that retard tidal flows, or directly, because their migration constitutes net sediment transport. Past studies of tidal dune dynamics have mainly focussed on identifying transport regimes and depth-scaling rules (e.g. Terwindt and Brouwer, 1986; Larcombe and Ridd, 1995; Kostaschuk and Villard, 1996; Larcombe and Jago, 1996; Cheng et al., 2004; Francken et al., 2004; Villard and Church, 2005; Bartholdy et al., 2005) or on exploring the relationship between measured rates of dune migration and predicted bedload transport rates (e.g. Hoekstra et al., 2004; Kostaschuk and Best, 2005; Williams et al., 2006). Considering the difficulty in determining net sediment transport in estuarine environments, surprisingly few investigations have utilised measurements of dune dynamics over extended periods of time to gain insight in net sediment transport patterns and ensuing implications for morphological development (Shepard and Hails, 1984; Allen et al., 1994; Gonzalez and Eberli, 1997; Whitmeyer and FitzGerald, 2008). It is, however, acknowledged that repeated, high-accuracy measurements of sedimentary bedforms has significant implications for long-term modelling of estuarine sediment transport (Bates and Oakley, 2004).

This paper uses field surveys of a dune field over a 3-month period complemented by measurements of tidal flows and water levels to gain insight into the net sediment transport rates and morphological development of an intertidal shoal in a small and shallow wave/tide-dominated estuary. Measured dune migration rates were converted to sediment transport rates and compared with volumetric transport predicted by empirical formulae. Because the dunes are only affected by flood currents, an expression of net transport rate as a function of the ocean tide range could be derived. Using tidal predictions, this expression was then used to estimate the annual net sediment transport over the shoal and the resulting morphological development.

2. Study area

The Avon estuary is located on the south coast of Devon in southwest England (Fig. 1). It is a relatively small estuary with a total surface area of 213.5 ha, of which 146.2 ha are intertidal, an estuarine

* Corresponding author.
E-mail address: gerd.masselink@plymouth.ac.uk (G. Masselink).

0025-3227/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.margeo.2009.03.009

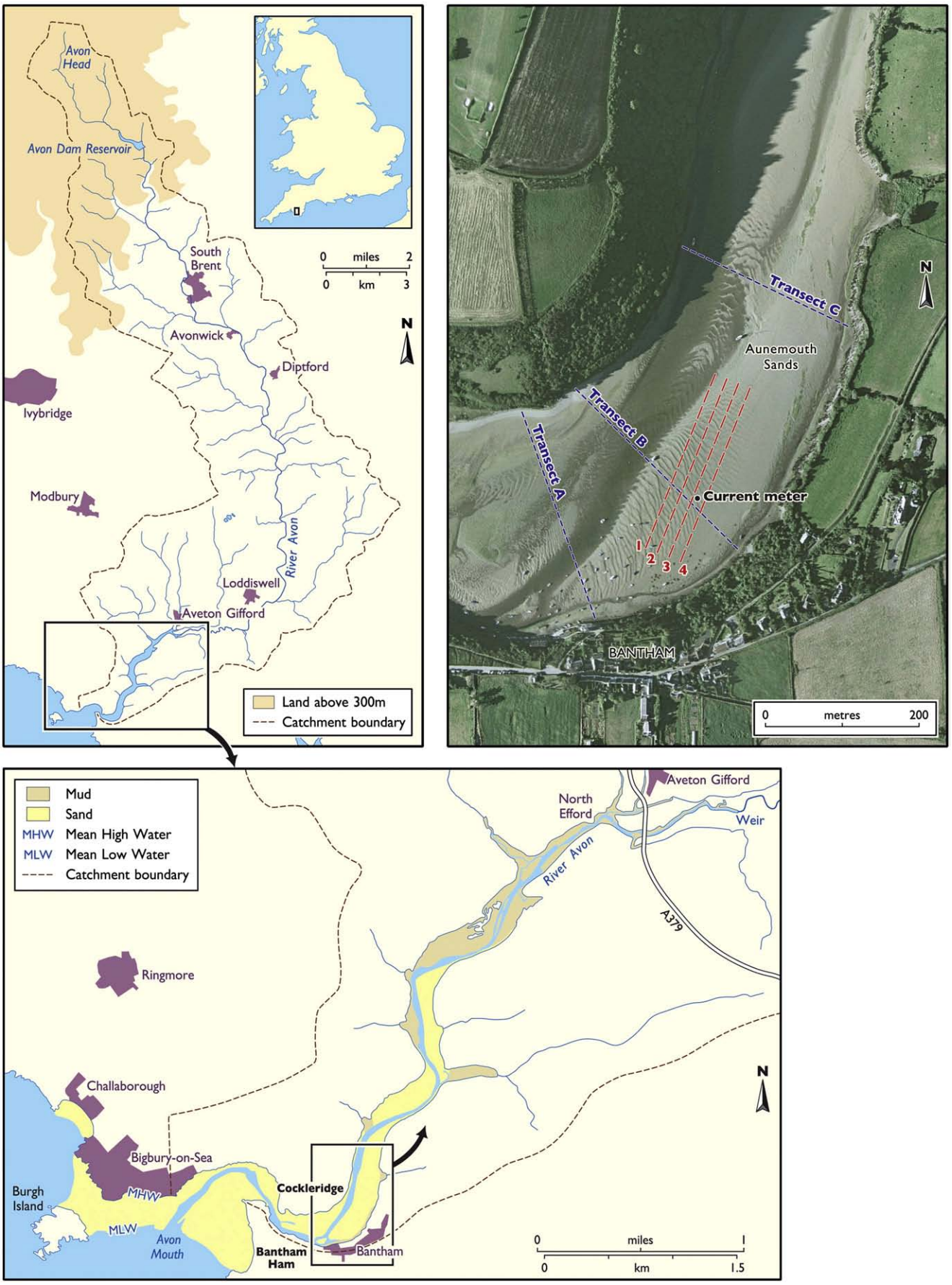

Fig. 1. Location map of the Avon estuary and aerial photograph of Aunemouth Sands showing the dune field, locations of cross-channel transects A–C, survey lines 1–4 and position of the current meter (photo from GoogleEarth).

Download English Version:

https://daneshyari.com/en/article/4719008

Download Persian Version:

https://daneshyari.com/article/4719008

Daneshyari.com