Continental Shelf Research 92 (2015) 23–36

Contents lists available at ScienceDirect

Continental Shelf Research

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

Research papers

Dynamics of inner-shelf, multi-scale bedforms off the south Aquitaine coast over three decades (Southeast Bay of Biscay, France)

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ARTICLE INFO

Article history:
Received 12 March 2014
Received in revised form
31 October 2014
Accepted 3 November 2014
Available online 8 November 2014

Keywords:
Sorted bedforms
Inner shelf
Aquitaine coast
Shoreward
Sand patches
Time lapse survey

ABSTRACT

This paper aims to investigate the seabed morphodynamics of the south Aquitaine inner shelf in the area known as "La Salie" (150 km^2, Atlantic ocean, west coast of France), through a descriptive and comparative analysis (time lapse of 29 years) of geophysical and sedimentological datasets.

At a water depth of 24–50 m, four orders of sedimentary body types were observed at different scales. The first order are large cross-shore "morphological ridges," corresponding with the properties of very large sorted bedforms. The second order consisted in patchy sorted bedforms, composed of alternately medium to fine sand patches (0.5–2 m in thickness), cut by smaller, elongated coarse sediment depressions. In particular, the data from the sub-bottom profiler revealed that sand patches predominantly overlayed the coarse-grained blankets on the eastern (shoreward) extremities, while coarse-grained blanket wedges were found in front of the sand patches (southwestward) or locally overlying them on the southwestern extremities. The third order of bedforms involved groups of dune-like features (fine/medium sand), lying in wide areas of coarse-grained sediment. Finally, in the fouth order, the entire inner shelf was covered with wave-generated ripples, oriented N15°, that were larger where sediments were coarse (wavelengths of 2.2 m) than where sediments were fine (wavelengths of 0.3 m). Over the past 29 years, at a large scale of observation, patchy sorted bedforms have remained remarkably persistent, as has their overall appearance. However, at a smaller scale, weak but constant movements were observed. The coarse depressions have become elongated at their extremities (by a maximum of 300 m over 15 years), and certain coarse/fine sediment boundaries have moved toward the northeast and southeast (by a maximum of 75 m over 12 years). The general movement has been shoreward as has the migration of third-order submarine dune-like features. The persistence of sorted bedforms thus appears to be the consequence of sediment sorting feedback and recurrent storm events.

1. Introduction

The inner continental shelf constitutes an area in which sediments can be permanently or temporarily stored. The sediments can experience alongshore transportation and/or be exchanged with the littoral zone or permanently lost toward the continental slope and deep basin. In the present context of the eustatic rise and erosion of sandy coasts, improving our knowledge of these exchanges and their associated processes appears to be of primary importance. As a first step, a better understanding of the morphodynamics of the inner continental shelf can help shed light on cross-shelf dynamics.

Some continental shelves with siliciclastic superficial sedimentary cover subject to intense hydrodynamic processes (storms or tides) display alternating bathymetric lows, such as coarse depressions or erosion furrows (coarse sand, gravel, and pebbles), and bathymetric highs, such as sand patches (medium to fine sand). These sedimentary structures have a relatively low topographic relief (1–2 m) (Murray et al., 2014; Murray and Thieler, 2004).

These sedimentary features, known as "sorted bedforms" (Murray and Thieler, 2004) or "rippled scour depressions" (Cacchione et al., 1984), are ubiquitously observed throughout the world. They do not always display a regular pattern (Ferrini and Flood, 2005) and exhibit a broad range of characteristics. Several

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http://dx.doi.org/10.1016/j.csr.2014.11.002
0278-4343/

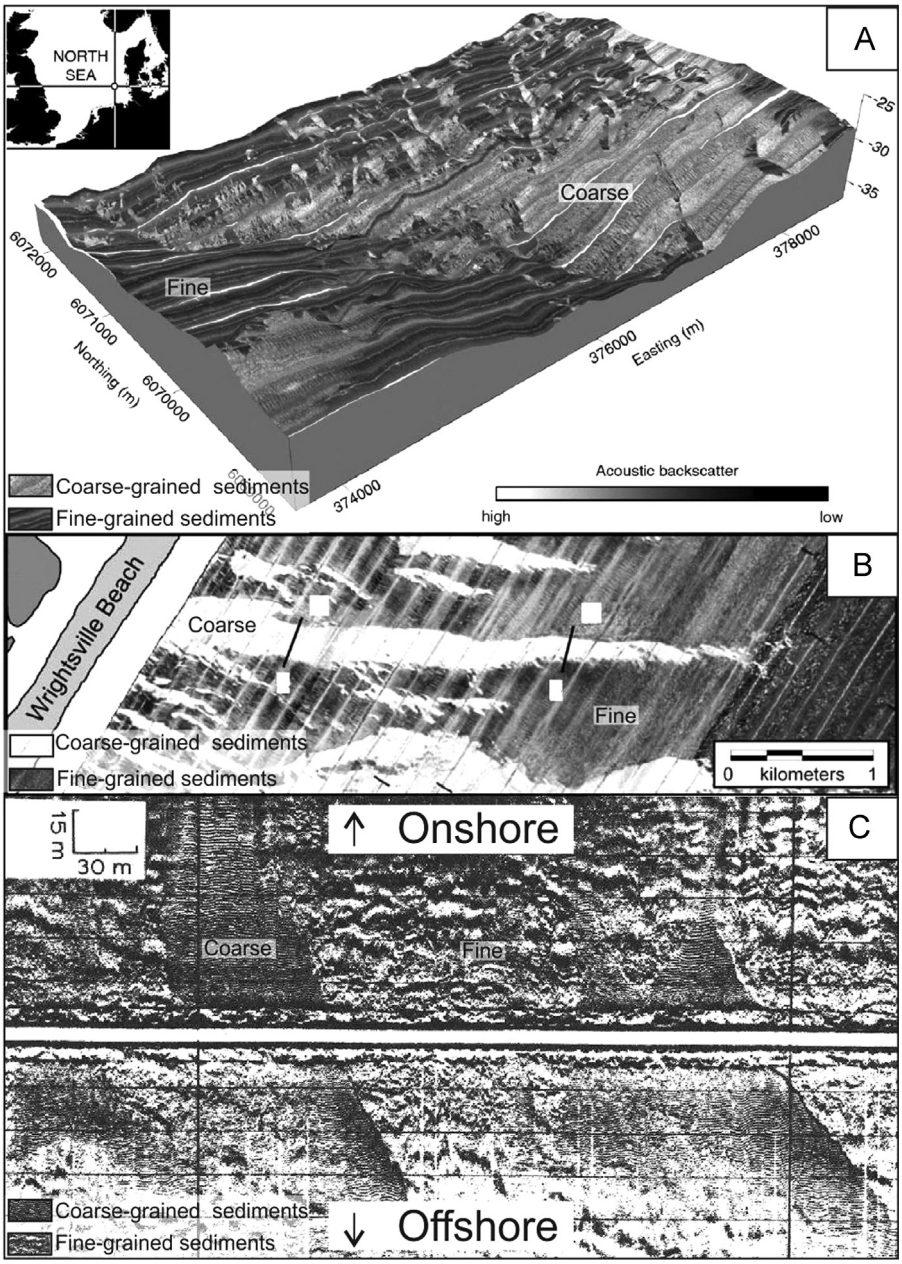

Fig. 1. Classification of sorted bedforms (Coco et al., 2007b). (A) Patchy (Diesing et al. 2006); (B) linear (Thieler et al., 2001); and (C) V-shaped (Morang and McMaster, 1980).

publications have proposed classifications for sorted bedforms (Coco et al., 2007b; Ferrini and Flood, 2005). Coco et al. (2007b) suggest that these seabed features can be classified into three types according to their shape: (1) patchy, (2) linear, and (3) offshore widening (or V-shaped) (Fig. 1). In this paper, we use this terminology, with a specific focus on patchy sorted bedforms.

Patchy sorted bedforms have been identified in numerous studies of continental shelves off the coast of Alaska (Hunter et al., 1982), the west coast of the United States (Davis et al., 2013; Eittreim et al., 2002; Ferrini and Flood, 2005; Hunter et al., 1988), the east coast of the United States (Thieler et al., 1999), the coast of New Zealand (Black and Healy, 1988; Hume et al., 2000; Trembanis and Hume, 2011), the coast of Germany (Diesing et al., 2006), the southern Baltic Sea (Schwarzer et al., 2003; Tauber and Emeis, 2005) and the French Aquitaine coast (Berné, 1999; Cirac et al., 1997, 2000; Turcq et al., 1986). These patchy sorted bedforms are found at a water depth of 4–90 m and have a low topographic relief with a vertical amplitude of under 2 m. Their spacing is very irregular, ranging from meters to kilometers, and their asymmetry and orientation also remain highly variable. Migration varies from site to site and grain size ranges from fine sand to pebbles. Moreover, Schwab et al. (2014) recently demonstrated on the northeast american inner shelf (offshore of Fire Island, New York) that such modern thin bedforms can lie uncomformably atop the Holocene ravinment surface and thus propose that such sediment starved seabed features can illustrate formation of a marine transgressive erosion surface.

On the Aquitaine continental shelf (Fig. 2B), patchy sorted bedforms have been the subject of numerous studies. Turcq et al. (1986) and Berné (1999) have described them as a sedimentary succession of sand patches, based on a coarse substrate, at a water depth of 30–90 m. The sand patches, which are irregularly shaped, are composed of fine to medium sand. They are rarely greater than 2 m in height and display a relatively flat surface with slightly asymmetric stoss and lee sides (Cirac et al., 1997, 2000). The coarse substrate is composed of coarse sand, gravel, and pebbles and