Continental Shelf Research xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Continental Shelf Research

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

Bottom morphology in the Song Hau distributary channel, Mekong River Delta, Vietnam

Mead A. Allison[a,b,*], H. Dallon Weathers III[a], Ehab A. Meselhe[a]

[a] The Water Institute of the Gulf, Baton Rouge, LA 70825, USA
[b] Department of Earth & Environmental Sciences, Tulane University, New Orleans, LA 70118, USA

ABSTRACT

Field studies in the Song Hau distributary of the Mekong Delta in Vietnam conducted at high (Sept.-Oct 2014) and low (March 2015) Mekong River discharge are utilized to examine channel bottom morphology and links with sediment transport in the system. Multibeam bathymetric mapping surveys over the entire channel complex in the lower 80 km of the distributary channel, and over 12- to 24-h tidal periods at six transect locations in the reach are used to characterize bottom type and change on seasonal and tidal timescales, supplemented by bottom sampling. The results of this study indicate that the largest proportion of channel floor (up to 80% of the total area) is composed of substratum outcrops of relict sediment units deposited during the progradation of the delta in the last 3.5 ka. These take the form of outcrops that are either (1) steep-sided, tabular channel floor, (2) steep-sided sidewall, or (3) relatively flat channel floor. Flatter outcrops of channel floor substratum are identified by the presence of sedimentary furrows (< 0.5 m deep) incised into the channel bottom that are exposed at high discharge and oriented along channel and laterally continuous for kilometers. These furrows are persistent in location and extent across tidal cycles and appear to be incised into relict units, sometimes with a thin surficial layer of modern sediment observable in bottom grabs. The extent of substratum exposure, greater than that observed previously in low tidal energy systems like the Mississippi River, may relate both to a relatively low sand supply from the catchment, and/or to an efficient transfer of both sand and mud through this tidally energetic channel. Sand bottom areas forming dunes, comprise about 19% of the channel floor over the study area and are generally less than a few meters thick except on bar extensions of mid-channel islands. Both sandy and substratum areas are mantled by soft muds 0.25–1 m thick during low discharge in the estuarine section of the study area. This mud mantling appears to be a key control on bottom sourcing of sand to suspension. An understanding of channel bottom morphology, particularly mobility and erodibility of sediments, is valuable for setting up morphodynamic models of channel evolution that can be used to test system response to anthropogenic alterations in the catchment and rising sea levels.

1. Introduction

The channels of major rivers in upland alluvial valleys are erosional features that convey sediment particles downstream, or when they exceed bankfull discharge, into the adjacent floodplain. The unidirectional stream power carves into the alluvium of previous channel-floodplain deposits, or occasionally during conditions that favor downcutting versus lateral migration, incise deeper into pre-channel belt strata (Mackey and Bridge, 1995). As these channels approach the ocean and water surface slopes are reduced approaching sea level, a major reduction in stream power and sediment transport capacity is observed except during large floods, when water surface slopes are elevated much closer to the land-sea interface. This backwater reach (Parker et al., 2009; Lamb et al., 2012) generally occurs upstream (as much as 100's of km) of the apex of the river's delta, that represents the point of alluvial thickening and distributary channel avulsion that deposits alluvium across a broad front (Slingerland and Smith, 2004). Gugliotta et al. (in this issue) define the backwater limit of the Mekong at about 650 km upstream in Cambodia where the river bed's elevation intersects with sea level. Another key energy consideration in the conveyance of river sediment to the ocean is the point at which the unidirectional river flow begins to be modulated by tides (i.e., flow always downstream but varying in velocity depending on diurnal and monthly phase). In low tidal energy systems like the Mississippi, this limit is reached downstream of the beginning of distributary bifurcation (Allison et al., 2014), while in more tidally energetic margins such

* Corresponding author at: The Water Institute of the Gulf, Baton Rouge, LA 70825, USA.
E-mail address: mallison@thewaterinstitute.org (M.A. Allison).

http://dx.doi.org/10.1016/j.csr.2017.05.010
Received 21 October 2016; Received in revised form 24 April 2017; Accepted 16 May 2017
0278-4343/

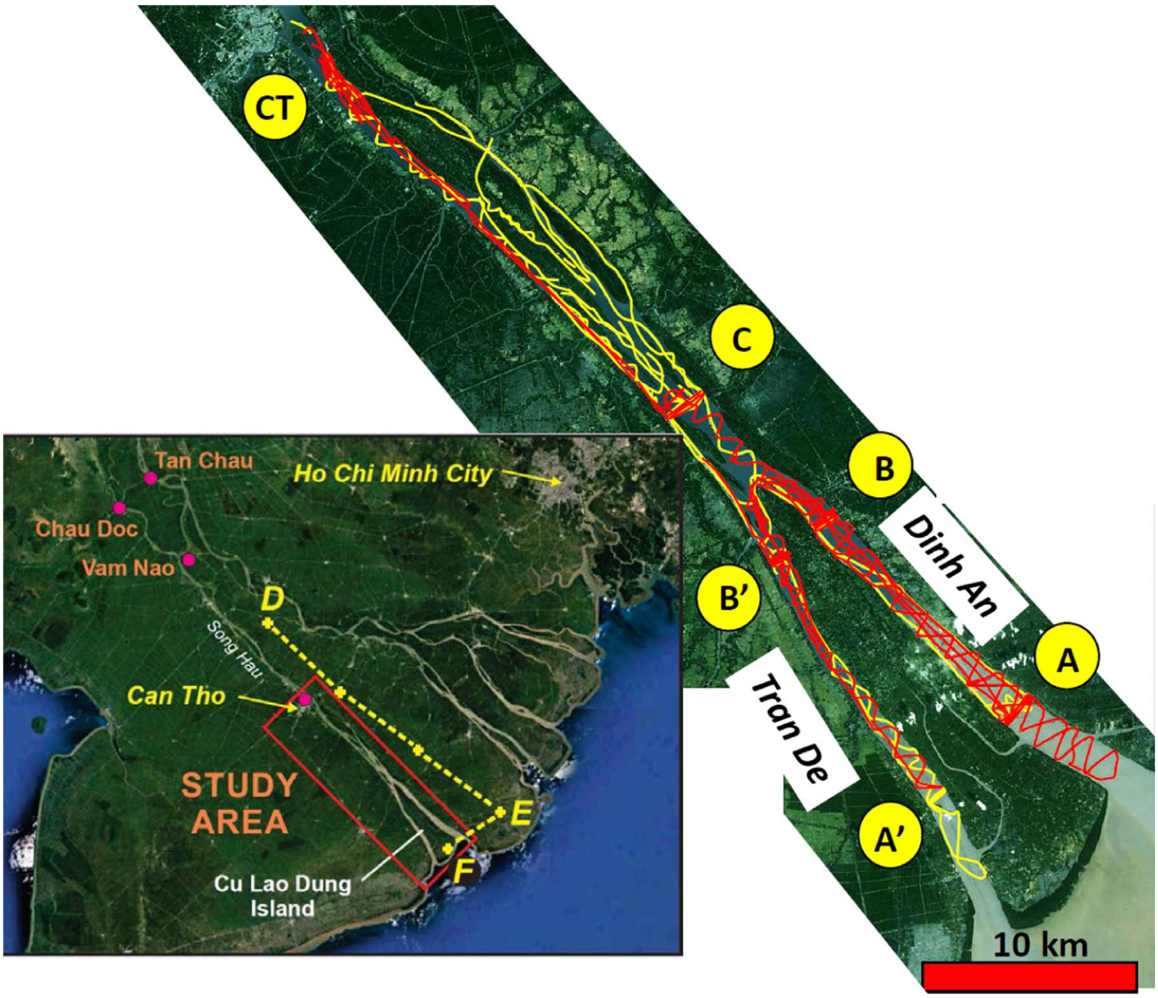

Fig. 1. Map of the study area (inset) including the locations of monitoring stations operated by Vietnam (purple circles) and the core transect discussed in the text (Transect D to E to F) from Ta et al. (2005). Large scale map shows the multibeam-LiDAR transects carried out in Sept-Oct 2014 (red) and March 2015 (yellow) and the location of the six transects where detailed studies were carried out (CT=Can Tho, C, B, B′, A, and A′). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

as in the Mekong system, tidal modulation can extend 100's of km's further inland than the deltaic apex. Gugliotta et al. (in this issue) demonstrate low discharge tidal modulation in the Mekong occurs upstream of the monitoring stations at Chau Doc and Tan Chau (Fig. 1) near the Vietnam-Cambodia border. In the Mekong and other tidally energetic major rivers (e.g., Changjiang, Amazon, Ganges-Brahmaputra), another key energetic boundary is the point that water flow changes from unidirectional but tidally modulated, to tidally reversing (e.g., upstream flow during the flood tide phase). A final boundary is the point at which saline water penetrates into distributary channel mouths. These two boundaries occur within the present Mekong study area. All of these energy boundaries in rivers migrate further downstream during higher riverine water discharges.

The reduction in fluvial energy and increasing importance of tidal energy in river channels approaching the land-sea interface has major implications for the throughput of sediment to the offshore delta. Channel bed morphology and its variation on tidal and seasonal hydrographic timescales is a means of examining the character and timing of this throughput. Field observational studies of bed character over this entire energy transition zone are also necessary to define bed strength and roughness parameters in numerical models (Xing et al., in this issue) that are used to predict channel and deltaic evolution. Accurate simulation of future conditions on deltas is critical at a time where many of these systems are heavily populated and are under increasing threat from alterations to sediment supply and the timing and magnitude of water discharge (damming, river control, deforestation of catchments) and relative sea level rise (Syvitski et al., 2009).

The primary objective of this study is to outline the spatial distribution of bottom morphology and sediment types on the channel floor of the Song Hau distributary of the Mekong River (Fig. 1), the largest distributary in terms of water flow in the Mekong delta (see Section 2 for details). Because many sites were mapped at both high and low river discharge and were re-occupied at different diurnal and spring-neap tidal phases, a second objective is to examine how channel floor sediment types vary downstream in the distributary channel with variable (1) bottom shear stress, (2) water and sediment input from upriver, (3) estuarine penetration and degree of water column stratification, and (4) geologic control of strata through which the channel is incised. A final objective is to compare the tidally energetic Song Hau distributary channel with the tidal-estuarine reach of other major river channels that are tide dominated (e.g., Fraser, Ganges-Brahmaputra, Changjiang) and microtidal (e.g., Mississippi) to examine overarching controls on deltaic distributary channel evolution. This study is a companion to other studies in this volume (McLachlan et al., in this issue, Stephens et al., in this issue, Xing et al., in this issue) that focus on the modern transport processes in the Song Hau distributary reach of the Mekong.