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Seasonal Changes in the Mekong River Delta's Distributary Channels and Nearshore Sedimentary Environments

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Award Number: N000141410113
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LONG-TERM GOALS

The long-term goal of our sediment transport and deposition investigations is to investigate how a tropical, tidal-dominated river transports and disperses sediment-laden flow through its heavily-vegetated and multiple-channelized delta plain. The research links the variation of riverine sediment flux to dynamic deposition and sediment accumulation patterns observed in the inner and middle shelves near the river mouth. The project will enable investigators to get a better understanding of the dynamic and seasonal transfer of riverine sediment from the source to sink.

OBJECTIVES

The specific objectives are:

1) To understand bathymetric features of the tide-dominated Mekong River Delta's distributary channels, banks, and nearshore environments;
2) To document the nature of sedimentation (deposition, erosion, accumulation) within the distributary channels of the Mekong Delta and associated nearshore environments;
3) To understand seasonal changes in the distribution of suspended matter, bottom muds, and sedimentary organic matter in the Mekong Delta's distributary channels and associated nearshore environments;
4) To provide ground truth for seasonal remote sensing signals;
5) To provide boundary data inputs and verification for coastal numerical modeling.

APPROACH

To establish the nature of sedimentation within and off the distributary channel of Song Hau on the Mekong Delta, we have proposed two surveys to characterize the water column and sedimentary regimes: one during the flood season (9/2014) and one during the dry season (3/2015).

Each survey includes the following research activities:

A) Conduct 16 cross-channel and 3 along-channel surveys on the Song Hau channel over a 150-km distance, landward from the river mouth coastal zone. (see Figs. 1);

B) Conduct 12 nearshore (<20 m water depth) surveys off the Song Hau river mouth, establishing a grid of measurements for 3-D interpretation of sedimentary and water column processes.

C) Collect 30 surface sediment samples, 12-15 gravity cores, and water samples from within the distributary channel system and nearshore delta plain deposits (see Fig. 1);

The specific field operations are as follows:

1) High-resolution seismic sonar, side scan and bathymetry surveys across- and along- the distributary channels. The sonar and bathymetric, side-scan and down-imaging surveys (as well as the coring efforts – see below) will be used to determine the geomorphology, distribution and thickness of deltaic muds within the channel system (Fig. 1).
2) CHIRP seismic profiles will be collected along the distributary channel surveys to reveal the spatial variations of the tide-dominated estuarine sedimentary processes.
3) Water sampling at 12 stations per cruise for suspended sediment concentration and organic carbon contents (TOC);
4) Collection of 1-3 meter long gravity cores for radiochemical analyses (^{14}C and ^{210}Pb), and measurements of dry bulk density, TOC, and grain-size. The radiochemical measurements of ^{14}C and ^{210}Pb will be used to assess whether deposition, erosion or net accumulation is occurring at a particular coring site. Radiochemical measurements will be made at 8 of the 20 coring stations collected during each of the field cruises.

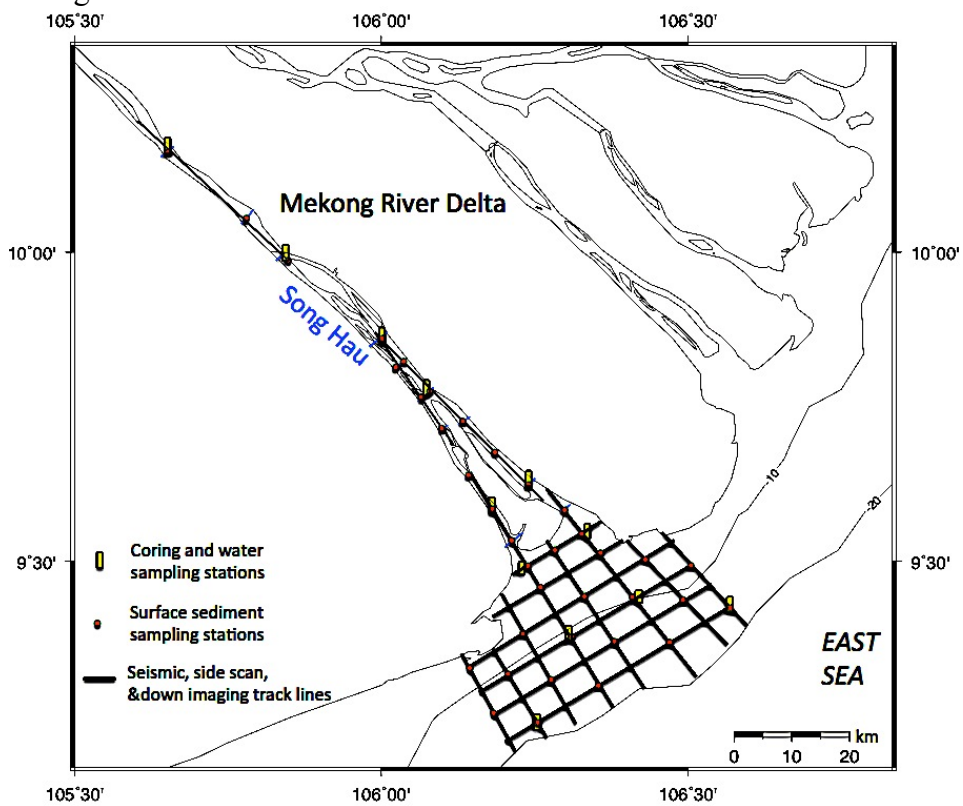

Figure 1. Proposed field survey lines (transect and seismic profiles) and sampling/coring stations across, along and off the Song Hau River.

WORK COMPLETED

To discuss the collaborations between the US scientists and Vietnamese scientists, plan and prepare the scientific research cruises, one meeting at AGU (12/2013) and one visit traveling to Vietnam (2/2014) have been made.

A research cruise off the Mekong River Delta and inside the Song Hau Rivever channels has just been conducted from September 24th to Oct 3rd, 2014. During the research cruise off the Mekong River Delta, NCSU researchers successfully collected 46 high-resolution Chirp sonar seismic profiles on the open shelf (see below). The total length of the profiles was 350 nautical miles, or ~650 km. In the north and south river channels of the Song Hau, an additional 54 nautical miles (100 km) of Chirp seismic profiles were collected to help understand the nature of sedimentation near the Song Hau river mouth.

Scientists from Vietnam, University of Washington, and North Carolina State University collected sediments (kasten cores and Shipek grab samples) from the open shelf between September 24th and September 30th, 2014. A total of 15 kasten cores were collected with sediment samples distributed to our Vietnamese collaborators (for sediment properties), our University of Washington colleagues (for short-lived radioisotopes, Th-234 and Be-7; Pb-210 analyses; grain size analysis; and other sedimentological measurements) and to NCSU scientists (for Pb-210 and C-14 analyses). Five Shipek grab samples were collected on the shelf.

Surface water samples were collected from a total of 19 Open Shelf stations and Song Hau River stations. These water samples were filtered through 0.45 micron cellulose acetate filters to determine suspended solid concentration (used to calibrate the OBS sensor on the UW CTD as well as interpret satellite imagery). In addition, at 5 of these stations surface waters were filtered through glass fiber filters (0.7 micron mesh) such that the particulate organic carbon (POC) contents of the surface waters could be determined.

Between September 30th and October 3rd, Vietnamese and NCSU scientists collected Chirp seismic profiles from the north and south channels of the Song Hau. During the river channel profiling, 13 surface sediment grab samples were collected (for grain size and bulk Pb-210 measurement). Three additional surface grab samples were collected from the open shelf (north of the river mouth) during the seismic profiling effort as the ship returned to port (Ho Chi Minh City).

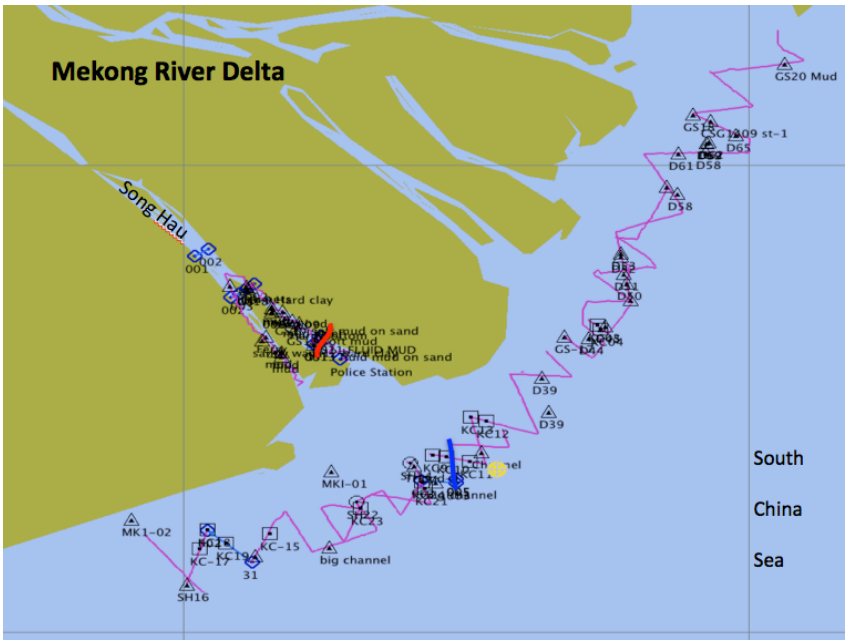

Figure 2. The recent research cruise seismic tracklines, sampling and coring stations on the shelf.

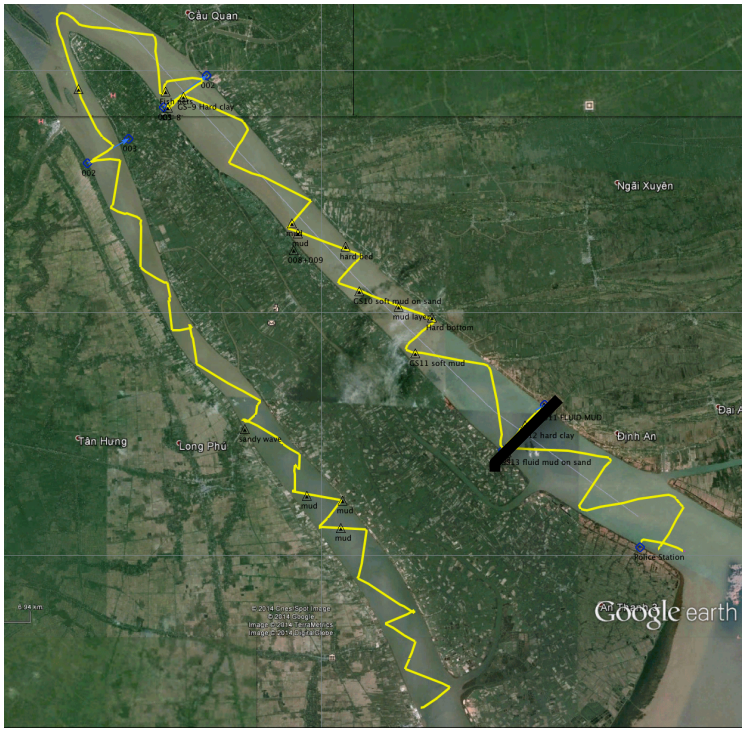

Figure 3. The seismic Chirp sonar survey tracklines. The location of a selected Chirp sonar seismic profile from inside the North Channel (Transect-A) is shown in this figure (see Fig. 5 for seismic profile).

RESULTS

The high-resolution Chirp profiles should enable us to develop a comprehensive 3-dimensional understanding of the Mekong delta's clinoform structure: (from the topset, to foreset, to bottomset beds). A selected Chirp seismic profile from Line 11 on the shelf (Fig.4) and a selected profile (Transect A) in the north channel (Fig.5) are shown below (see locatiions on Figs 2 and 3).

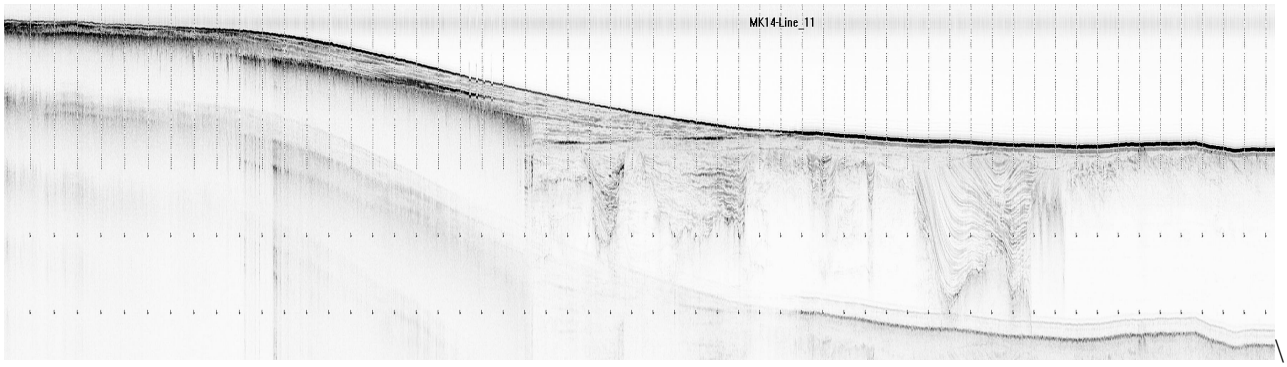

Figure 4. A selected seismic Chirp sonar profile on the shelf.

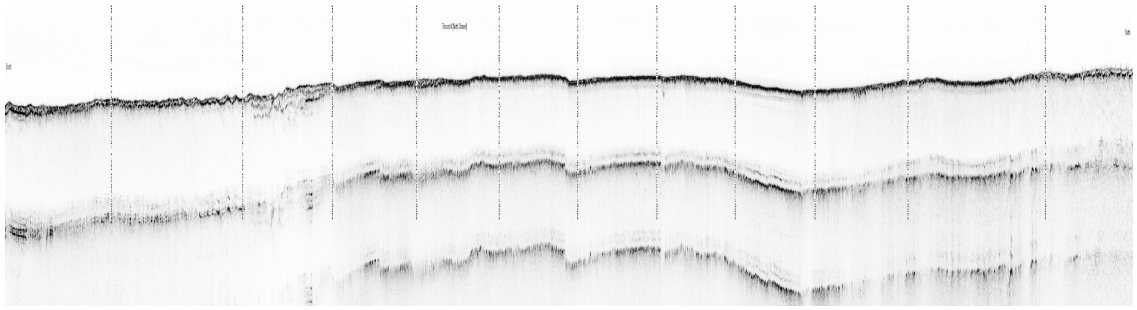

Figure 5. A selected seismic Chirp sonar profile in the north channel of the Song Hau, Mekong River.

The preliminary analysis of our seismic profiles show the Mekong River's deltaic sediment mainly deposited across the shelf within water depths less than 20 m. The deltaic sediments have formed a typical clinform structure with topset, foreset and bottomset beds.

The geochecmical analysis for the cores and water samples are currently in progress.

IMPACT/APPLICATIONS

By comparing high resolution seismic profiles, water depth profiles, the water column measurements, and the coring results from the two field cruises (one summer and one winter), seasonal contrasts in depositional and erosional regimes can be assessed. In addition, temporal variations in the nature of the channel morphology can be determined as well as any potential temporal variability in the distributions of deltaic muds within the distributary channels. The replication of the sonar profiles just seaward of the subaerial delta plain should document whether or not the leading edge of this tide-dominated deltaic system is prograding or eroding over time. These data, coupled with the geochronological measurements, will be used to assess the overall nature of sedimentation in this tide-dominated deltaic system, particularly examining their seasonal differences.

TRANSITIONS

The initial results of this research effort on the Mekong River delta shelf and river channels will be transferred to our Vietnamese colleagues and to our ONR collaborators on the project. The high-resolution Chirp sonar profiles should provide a 3-D understanding of the distribution, thickness and sequence stratigraphy of the Mekong deltaic clinoform. The geochemical analyses, sediment deposition and accumulation rates, sediment distribution and budgets, and grain-size data will be key input parameters for numerical models examining sediment dynamics on the Mekong shelf.

RELATED PROJECTS

Related projects in the Tropical Deltas DRI are underway by C. Nittourer, A. Ogston, M. Allison D. Roelvink and S. Jachec.

PUBLICATIONS

1) Paul Liu, 2014. Fates of Asian river-derived sediments to the sea: Large vs small rivers. Ocean Science Meeting, Abstract.

2) Paul Liu, 2014. Fluxes and Fates of World Major Rivers to the Sea: their biogeochemical implications. World Large River Conference. Abstract.
3) Paul Liu and Chi Lu, 2014. Natural and Human Impacts on Recent Development of Asian Large Rivers and Deltas. AGU-fall, Abstract.
4) Chi Lu, 2014. Natural and Human Impacts on Recent Development of Yangtze River and Mekong River Deltas. MS thesis, NCSU.
5) Chi Lu and Paul Liu, 2014. Natural and Human Impacts on Recent Development of Asia Large Deltas: Case study of the Yangtze River and Mekong River, submitted.