

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

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### **LONG-TERM GOALS**

The long-term goal of our sediment transport and deposition investigations is to investigate how a tropical, tide-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:

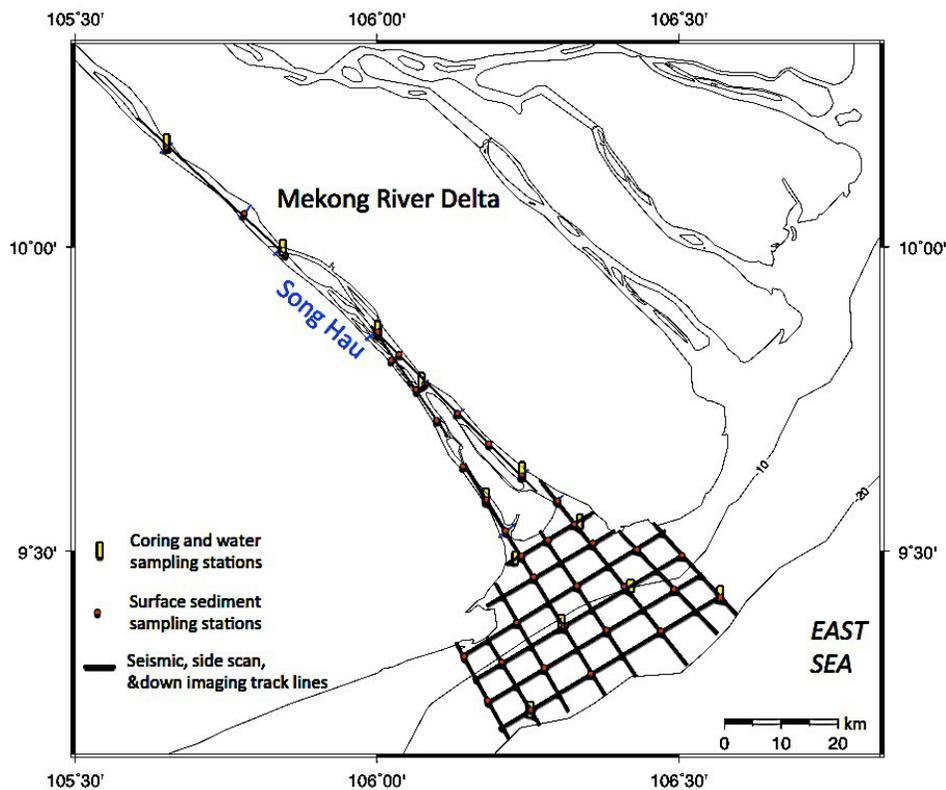
- A) Conduct nearshore (<20 m water depth) surveys off the Song Hau river mouth, establishing a grid of measurements for 3-D interpretation of sedimentary and water column processes.
- B) Collect surface sediment samples, gravity/kasten cores, and water samples from within the

distributary channel system and nearshore delta plain deposits (see Fig. 1);

- C) Collect surface sediment samples, gravity/kasten 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/kasten cores for radiochemical analyses ( $^{14}\text{C}$  and  $^{210}\text{Pb}$ ), and measurements of dry bulk density, TOC, and grain-size. The radiochemical measurements of  $^{14}\text{C}$  and  $^{210}\text{Pb}$  will be used to assess whether deposition, erosion or net accumulation is occurring at a particular coring site.



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

## WORK COMPLETED

Two research cruises off the Mekong River Delta and inside the Song Hau River channels were conducted during late September 2014 and March 2015. During the 2014 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 (Fig.2).

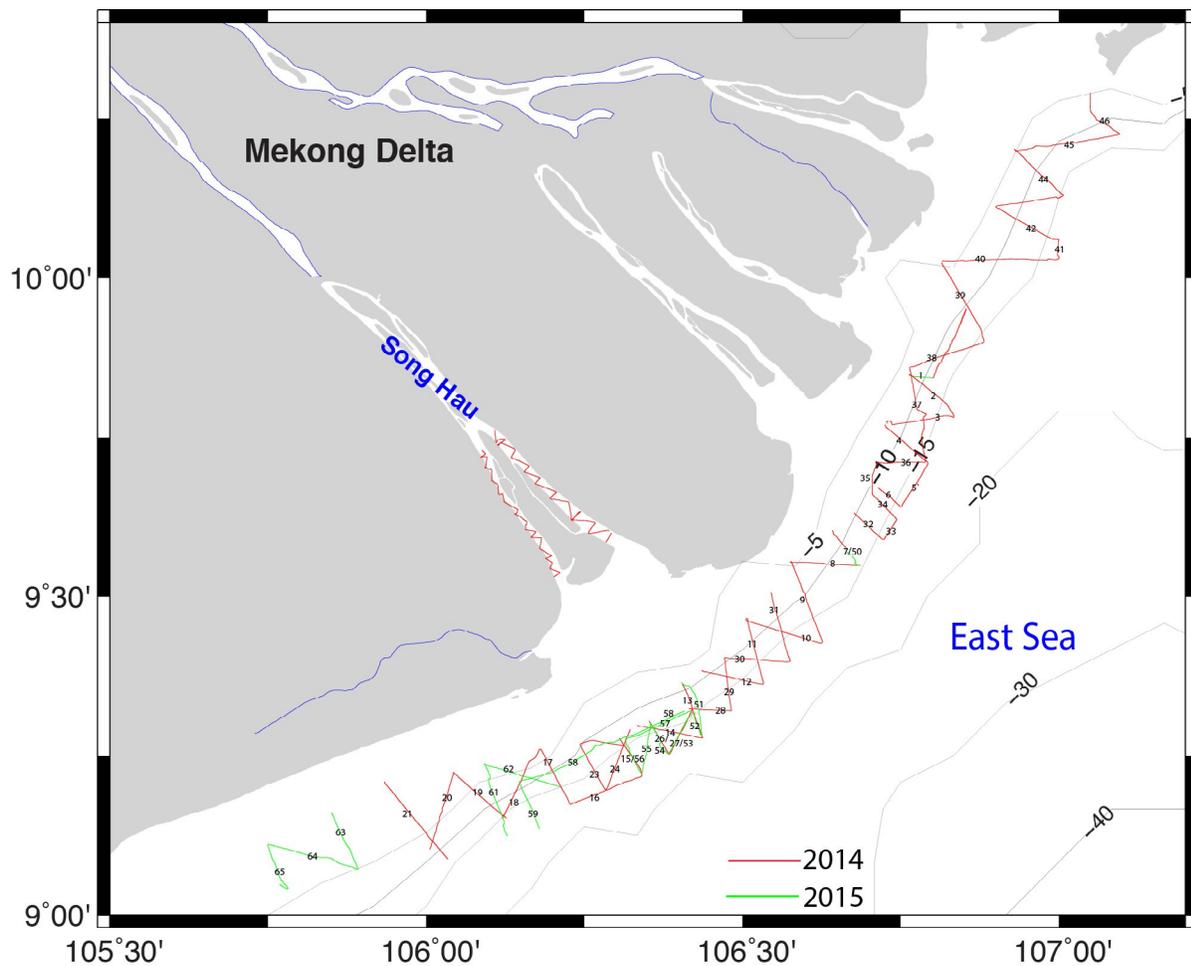
Scientists from Vietnam, University of Washington, and North Carolina State University collected sediments (kasten cores and Shipek grab samples) from the open shelf between September 24<sup>th</sup> and September 30<sup>th</sup>, 2014. A total of 15 kasten cores were collected, with sediment samples 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 30<sup>th</sup> and October 3<sup>rd</sup>, we 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).

During the March 2015 research cruise off the Mekong River Delta, NCSU researchers successfully collected 16 high-resolution Chirp sonar seismic profiles (lines 50-66) on the open shelf (see below Fig. 3 ). The total length of the profiles was 200 nautical miles, or ~360 km.





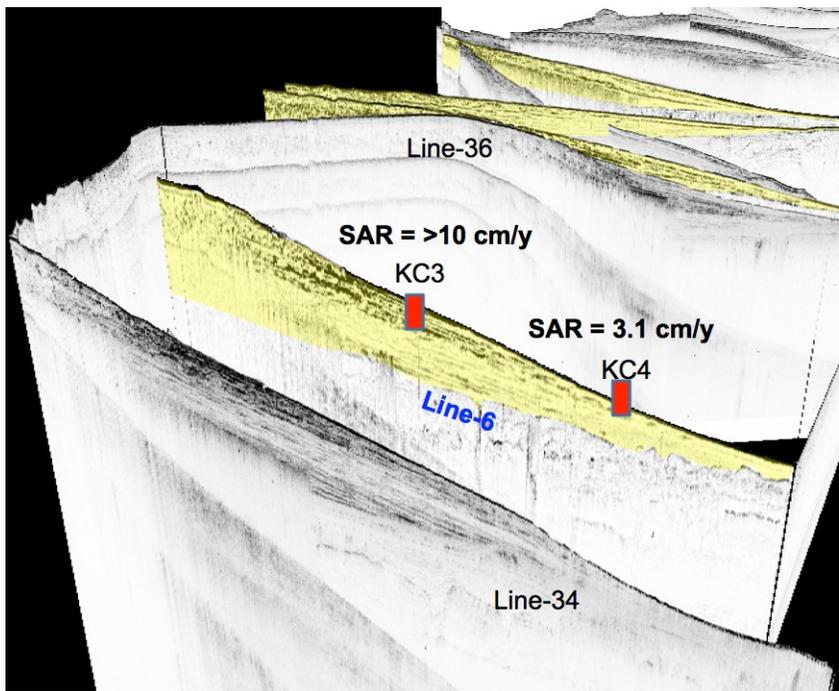
**Figure 3. The 2014-2015 cruise survey tracklines.**

All CHIRP sonar seismic profiles have been post processed, saved as a common jpeg format, and further possessed into a 3D diagram view for interactive visualization (see Fig. 4).

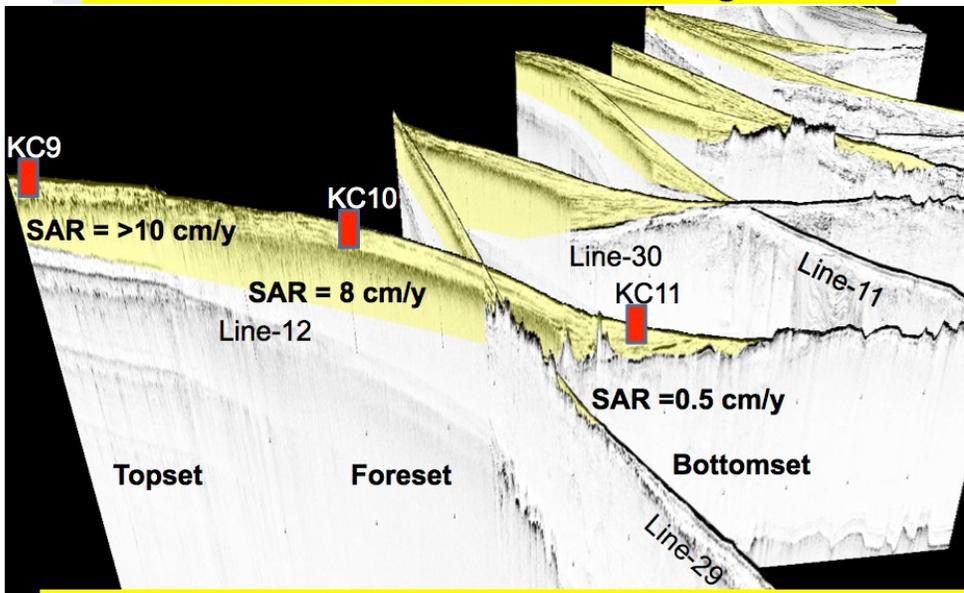
Sediment samples from cores KC3, KC4, KC9, KC10, KC11, KC12, KC13, KC17, KC15, KC18, KC23, KC51, KC55, KC56, KC57, KC58, KC73, KC74, KC77, KC78, and KC79 have been processed in the lab for  $^{210}\text{Pb}$  analysis. KC3, KC4, KC9, KC10, KC11, KC12, KC17, KC23, KC77, KC79 were analyzed for  $^{14}\text{C}$  geochronology, based on the  $^{14}\text{C}$  signal in the sedimentary organic carbon fraction (see some results in Table -1).

## 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). Some selected CHIRP seismic profiles from Lines 6-65 on the shelf (Fig.4) are shown below (see locations on Fig 3).



**Offshore Trends in SAR North of Song Hau River**



**SAR and Clinoform Structure Near Song Hau River**

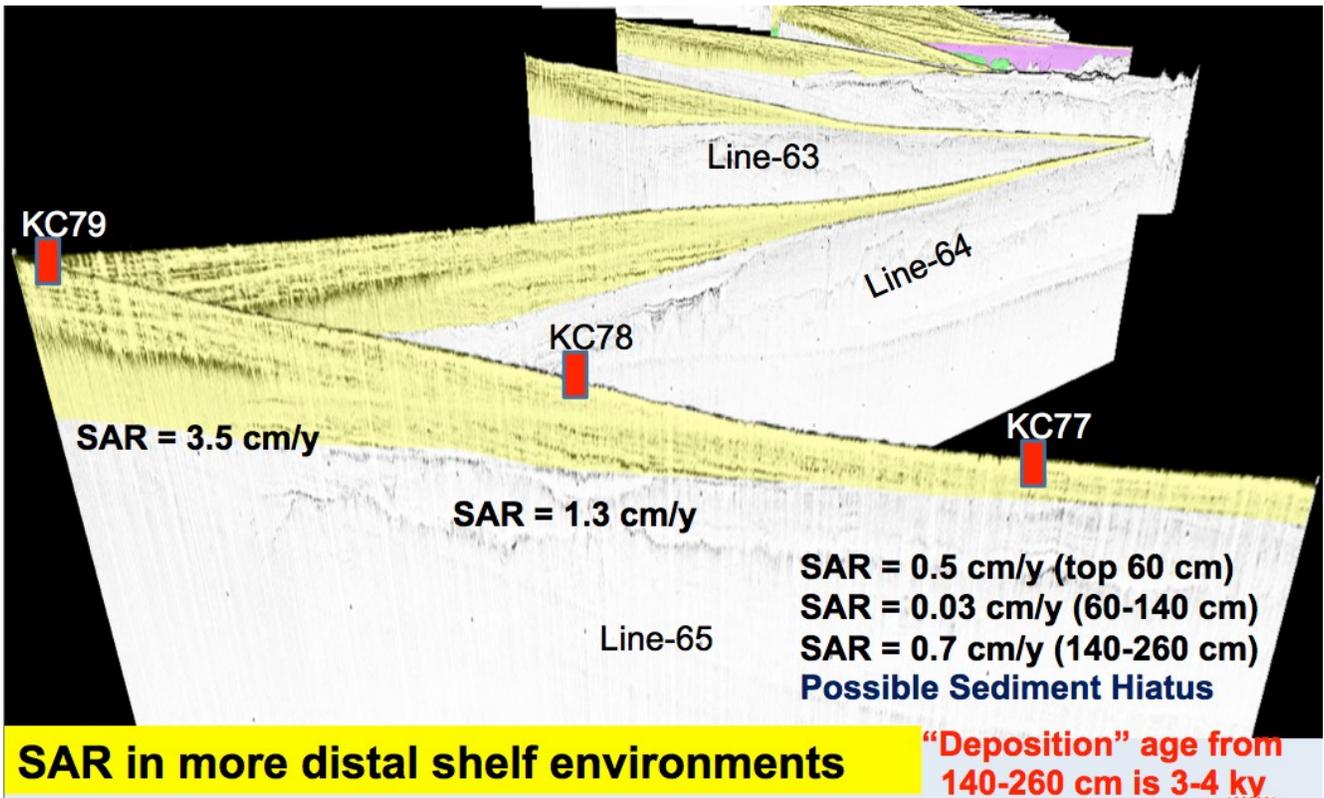
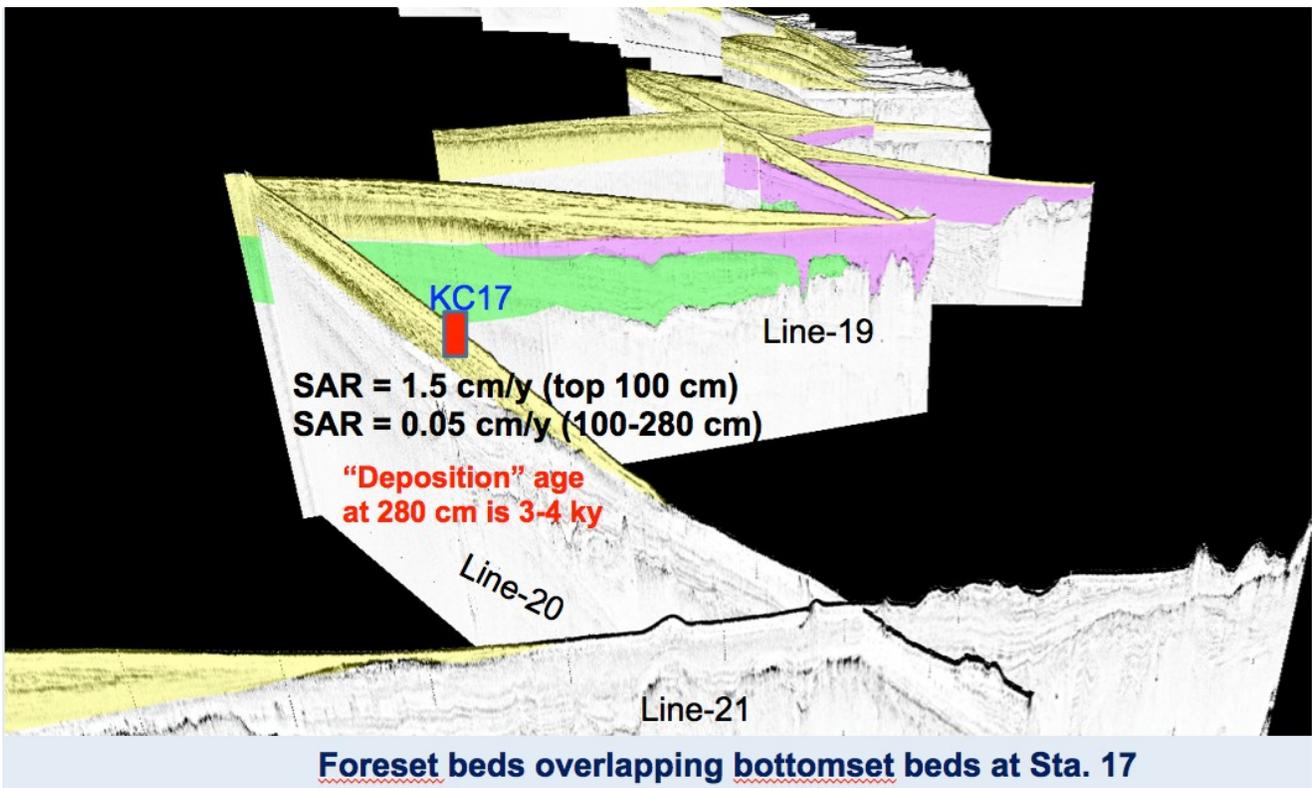


Figure 4. Selected seismic CHIRP sonar profiles on the shelf with  $^{210}\text{Pb}$  derived accumulation rates.

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.

*Table 1: The geochemical analysis results ( $^{210}\text{Pb}$  and  $^{14}\text{C}$ ) from the Kasten cores.*

MEKONG SHELF SEDIMENTATION RATES					
Core	$^{210}\text{Pb}$ SAR	XS $^{210}\text{Pb}$	$^{210}\text{Pb}$ Linearity	$^{14}\text{C}$ <50cm	Agreement
	cm/y	Penetrat. cm		$^{14}\text{C}$ Core SAR (cm/y)	
KC3	V. High	213	Poor	V. High	Compatible
KC4	3.1	237	Excellent	V. High	Compatible
KC9	V. High	280	Poor		
KC10	7.9	293	Fair	V. High (0.31)	Compatible
KC11	0.51	43	Very Good	V. High	Compatible
KC12	V. High	(47)	Poor	V. High (0.10)	Compatible
KC13	2.3	(103)	Fair		
KC15	2	(45)	Very Good		
KC17	1.5	(63)	Good	V. High 0.052	Compatible
KC18	0.9	(51)	Fair		
KC23	V. High	(47)	Poor	V. High	Compatible
KC51	3.2	275	Good		
KC77	0.46	50	Excellent	V. High 0.028	Compatible
KC78	1.3	50	Good		
KC79	3.5	150	Very Good	V. High (0.22)	Compatible

## **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 has been and will continue to 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. Nittrouer, A. Ogston, M. Allison, D. Roelvink, and S. Jachec.

## **PUBLICATIONS**

- 1) Paul Liu and Chi Lu, 2014. Natural and Human Impacts on Recent Development of Asian Large Rivers and Deltas. AGU-fall, Abstract.
- 2) Paul Liu, 2015, Flux and fates of Asian major river derived sediments to the sea, Asian Marine Geology Conference, Abstract. [We could add the titles of our 2 Ocean Sciences abstracts, but they have not been officially accepted yet]
- 3) D. DeMaster, J.P. Liu, C. Nittrouer, E. Eidam, and N. Thanh, 2016. Establishing rates of sediment accumulation on the Mekong shelf: Radiochemical approaches based on  $^{210}\text{Pb}$  and  $^{14}\text{C}$  distributions. Abstract for 2016 Ocean Sciences Meeting, New Orleans (Feb. 2016).