Suspended Sediment Character in the Tidal Mekong River: Observations from LISST Profiling

Diana R. Di Leonardo, Mead Allison, Robin McLachlan, Andrea Ogston

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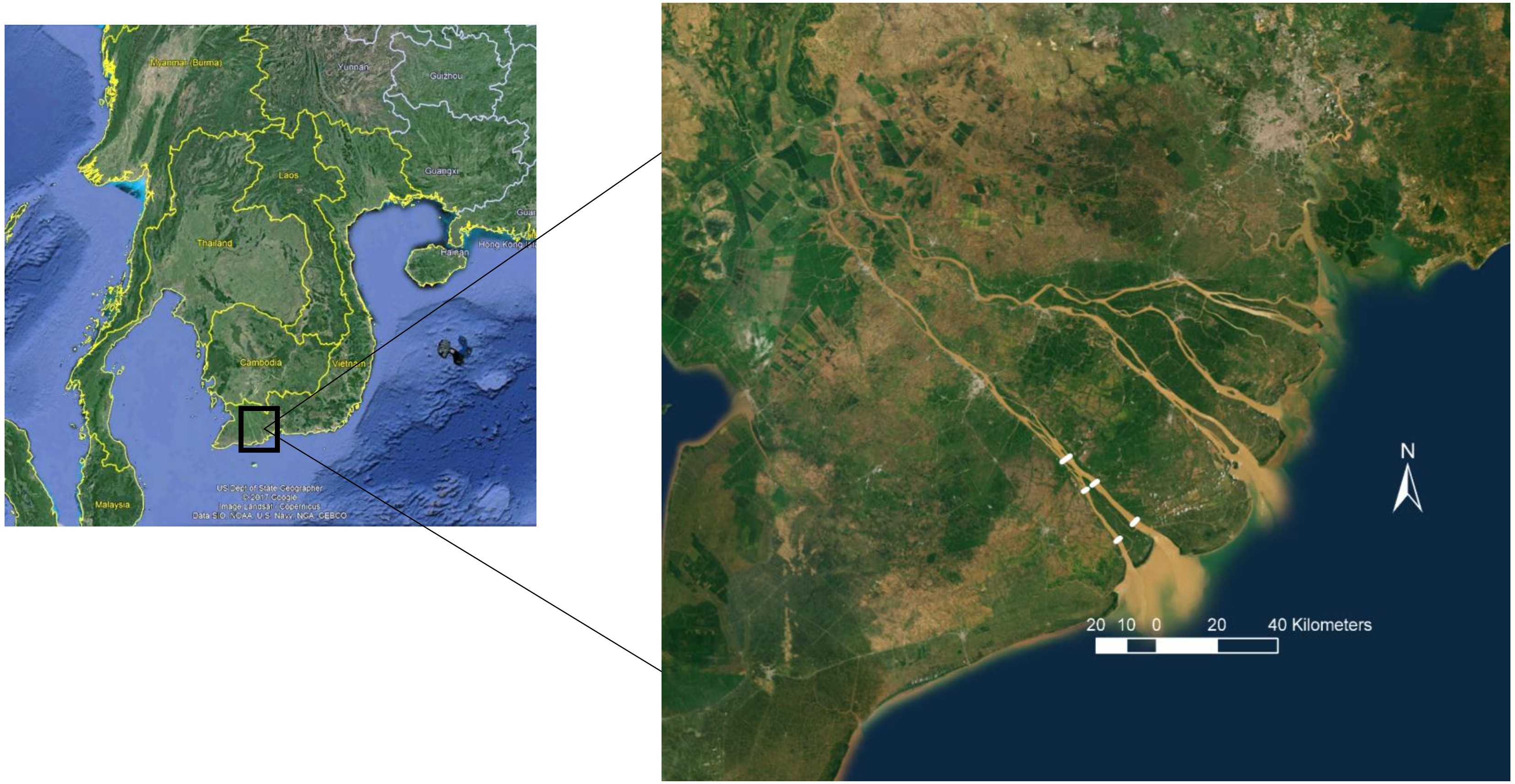
Introduction

- Sediment character affects our understanding of the dynamics of river systems.
- Flocculation is important, but difficult to measure.

Objectives:

- 3 independent measures of sediment grain size and concentration
- Describe patterns in sediment character:
    1) sediment concentration with depth and tide
    2) particle size with depth and tide
    3) floc percentage and size with salinity

Study Area – Tidal Mekong River



- 8 major distributary channels

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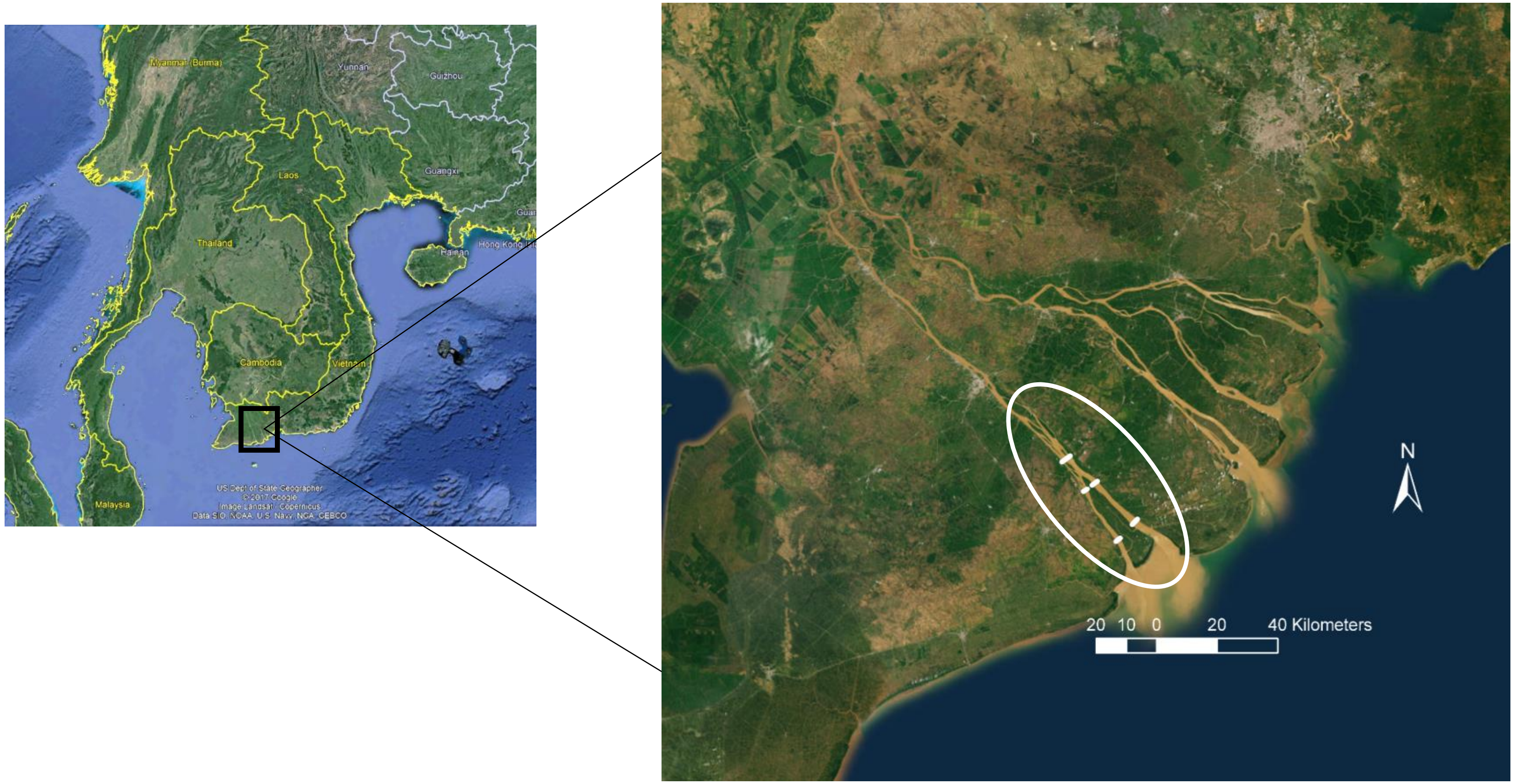

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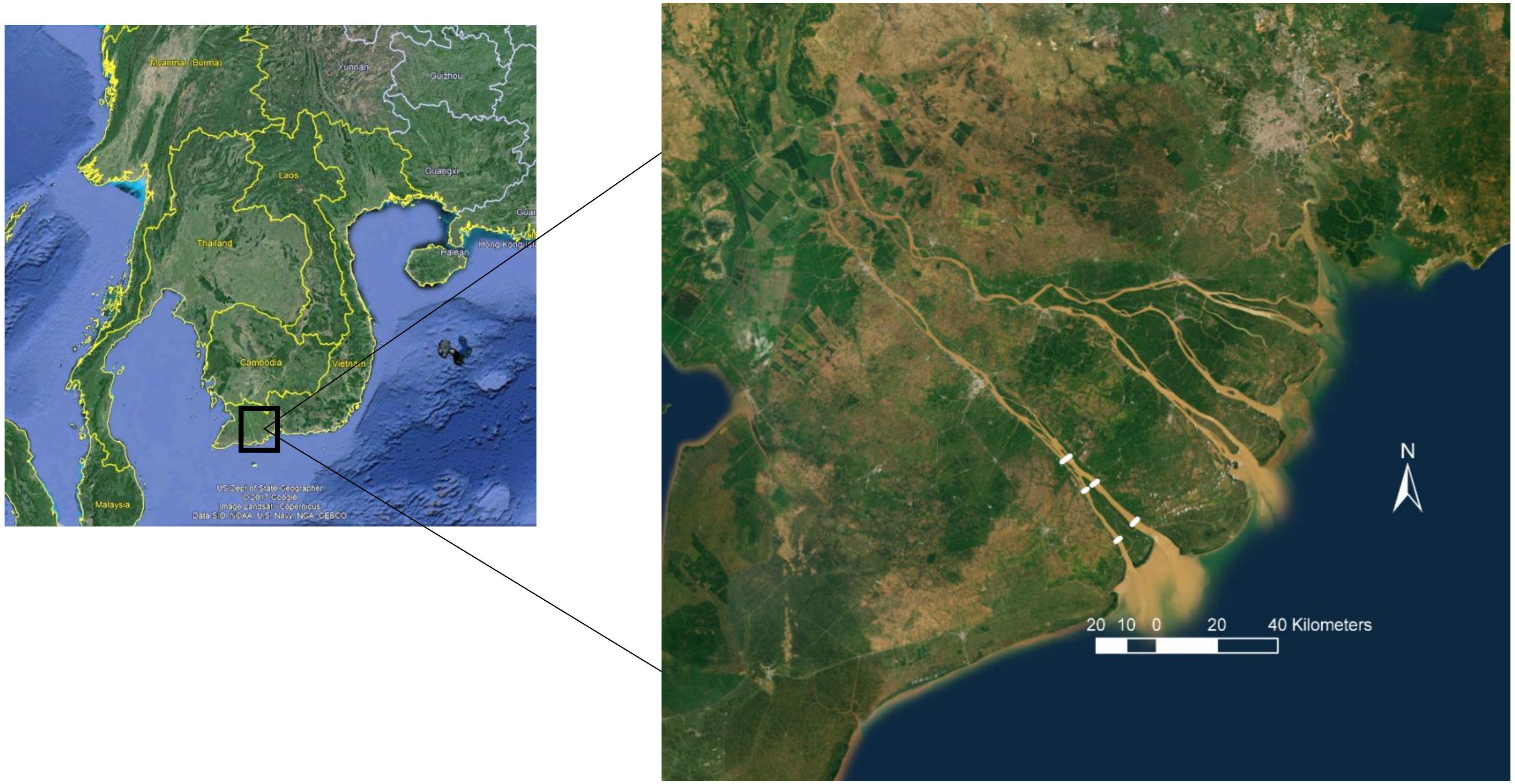

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- Drainage basin:
  0.79×10^6 km^2
  (52nd largest)

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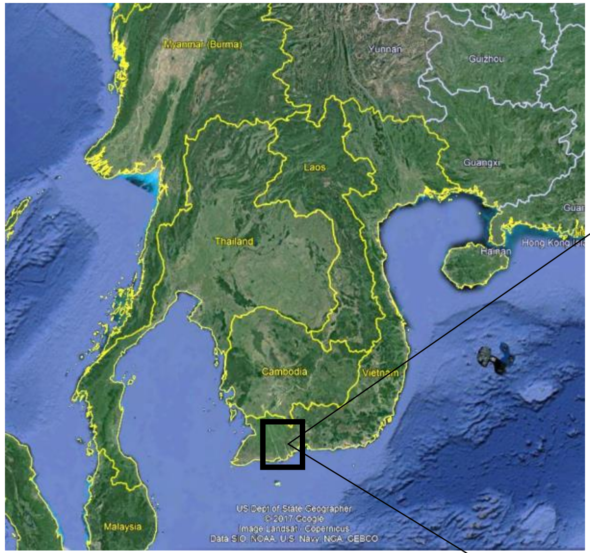

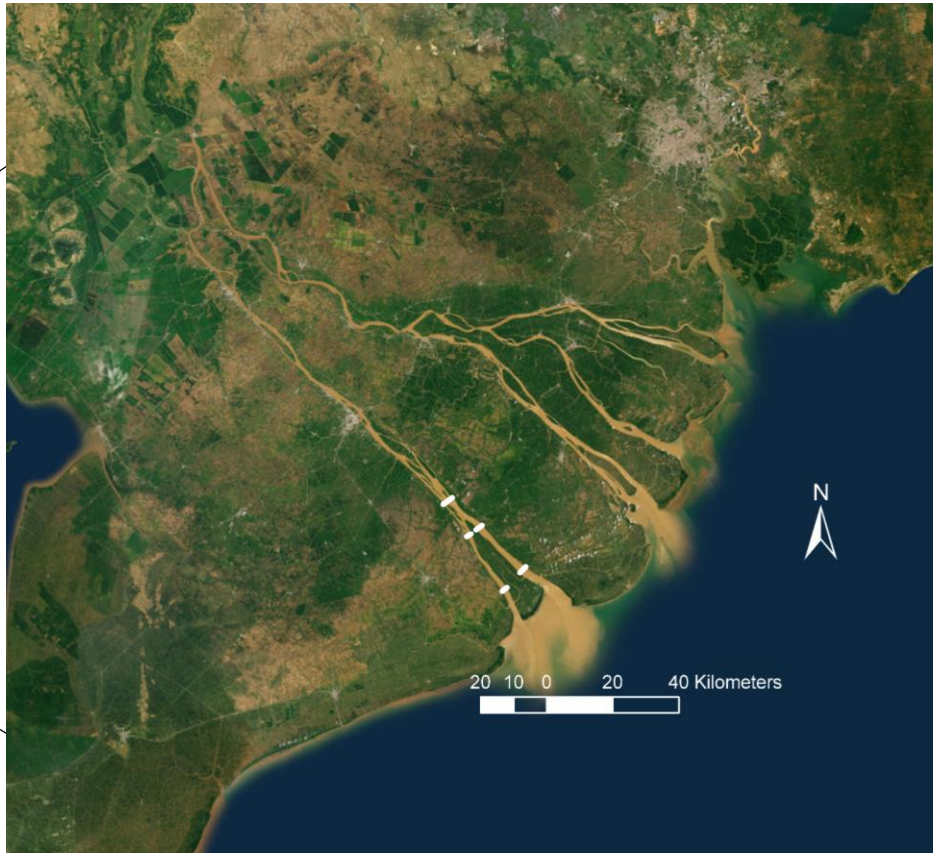

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  - 3.5 m maximum range

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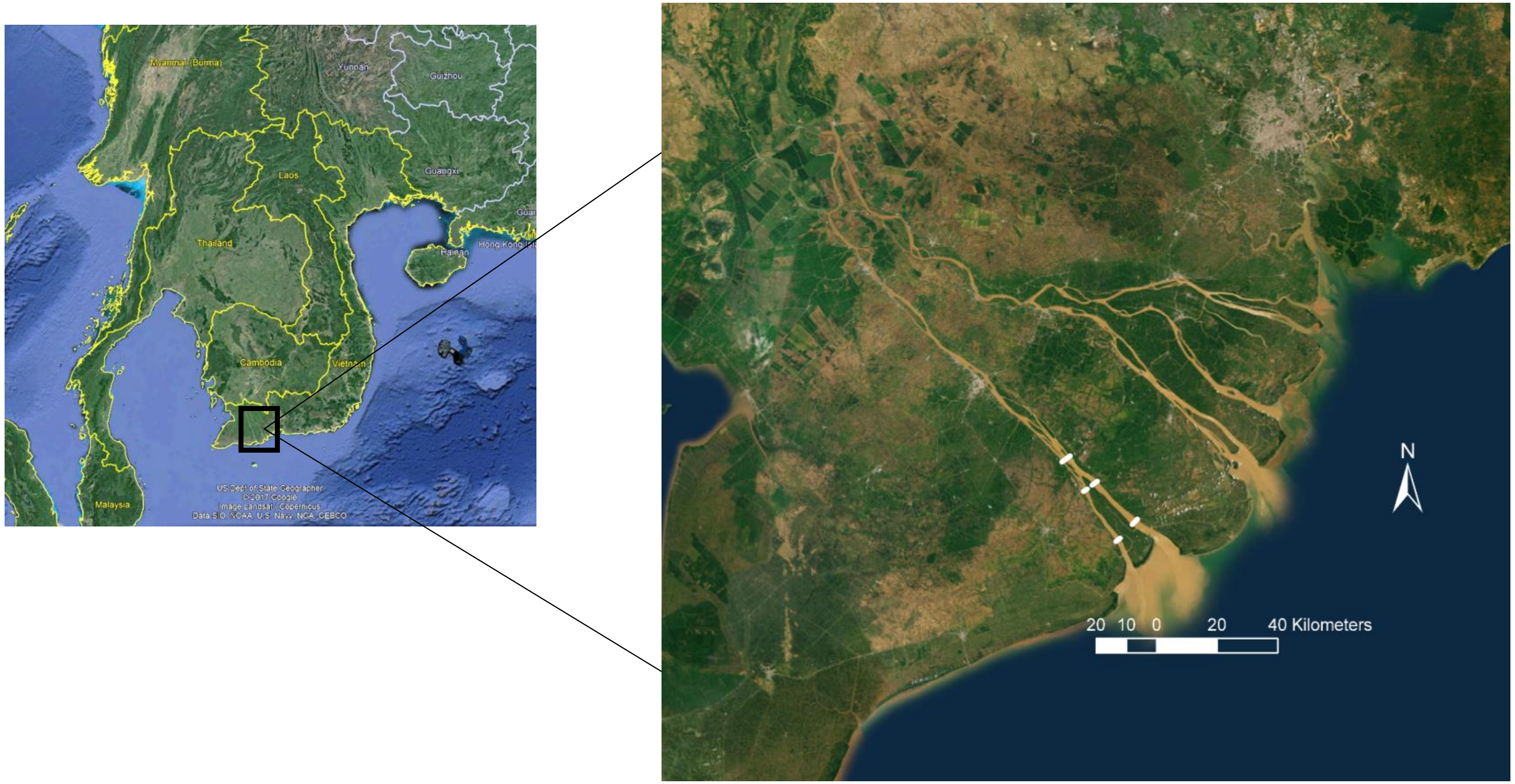


- 8 major distributary channels
- Drainage basin:
  0.79×10^6 km^2
  (52nd largest)
- Mixed Semidiurnal
  - 3.5 m maximum range
- Monsoonal climate
  - Fall high Q
  - Spring low Q

Mekong River

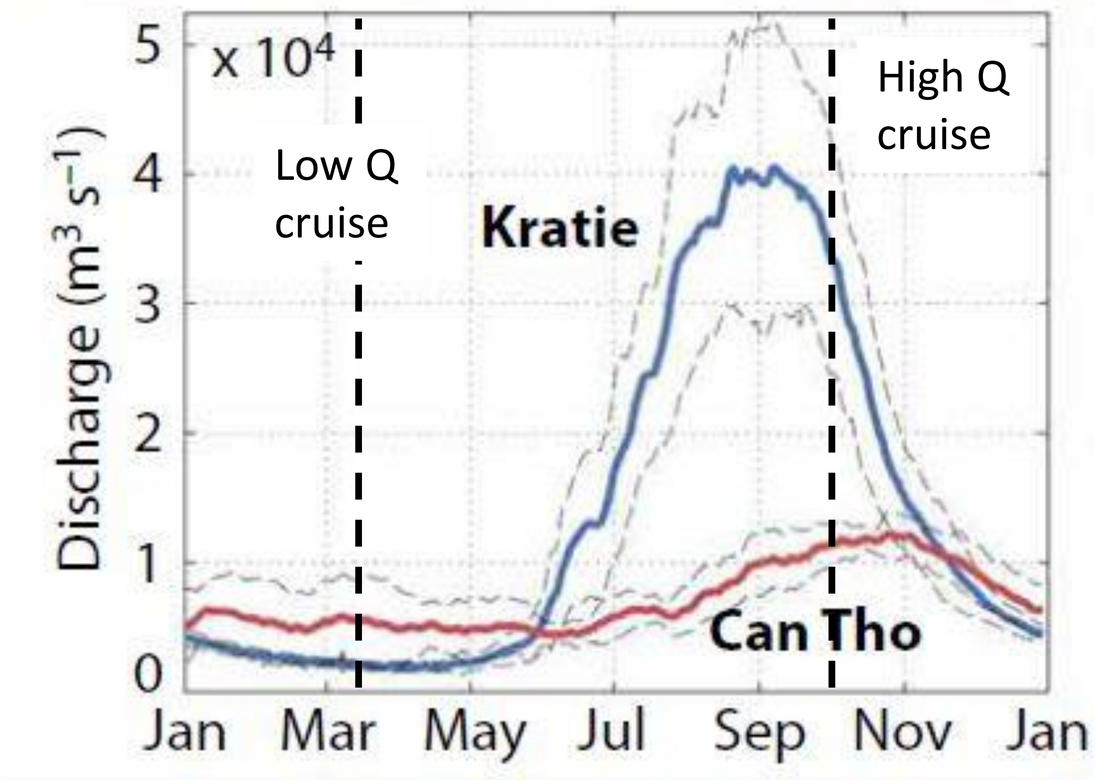
- Discharge

Song Hau Distributary

- 5,000 to 12,000 m^3/s
- Dinh An
- Tran De

Median high Q
Mississippi River:
22,600 m^3/s (USGS)

Columbia River:
11,300 m^3/s (USGS)



Ogston et al. (2017)

Mekong River

- Discharge

Song Hau Distributary

- 5,000 to 12,000 m^3/s
- Dinh An
- Tran De

Median high Q Mississippi River: 22,600 m^3/s (USGS) Columbia River: 11,300 m^3/s (USGS)

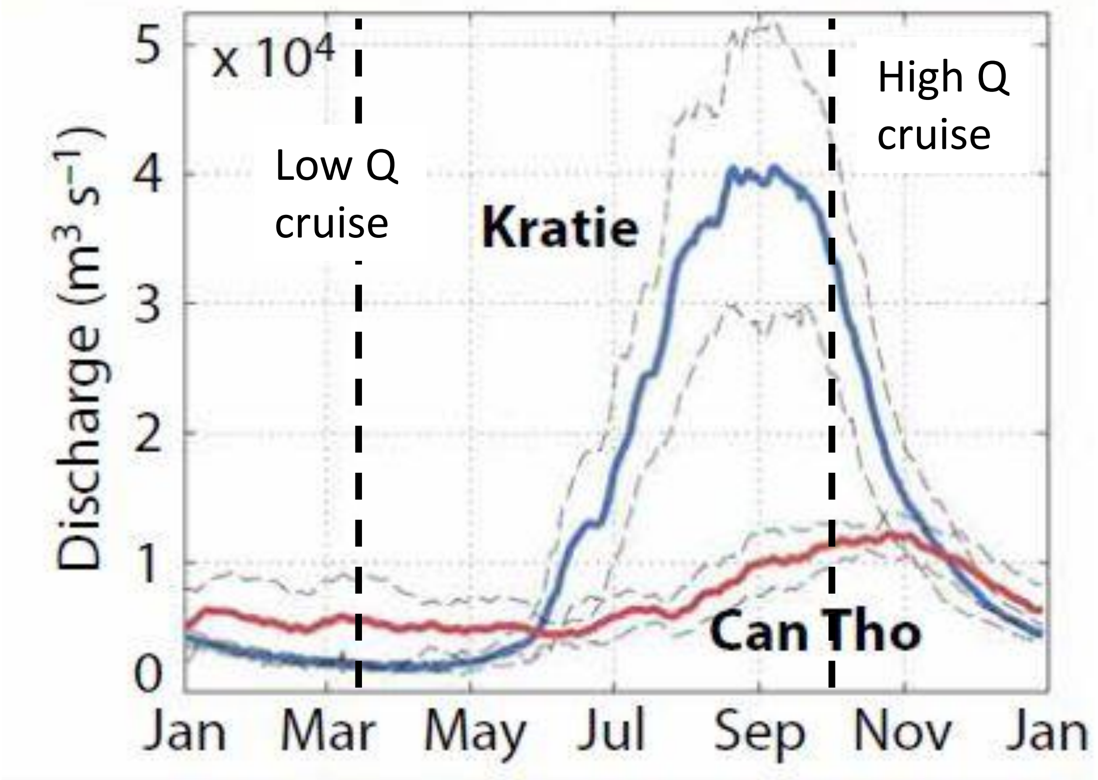
- Sediment Load:

~40 Mt/yr

- Clay and silt
- Sand during high Q

(Nowacki et al. 2015)

Mississippi River: 159 Mt/yr (CWPRA) Columbia River: 5 Mt/yr (USGS)



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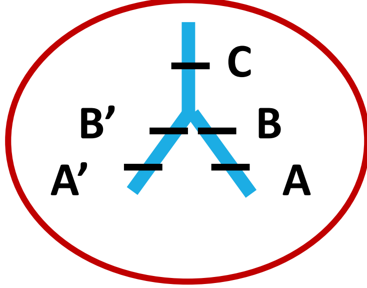
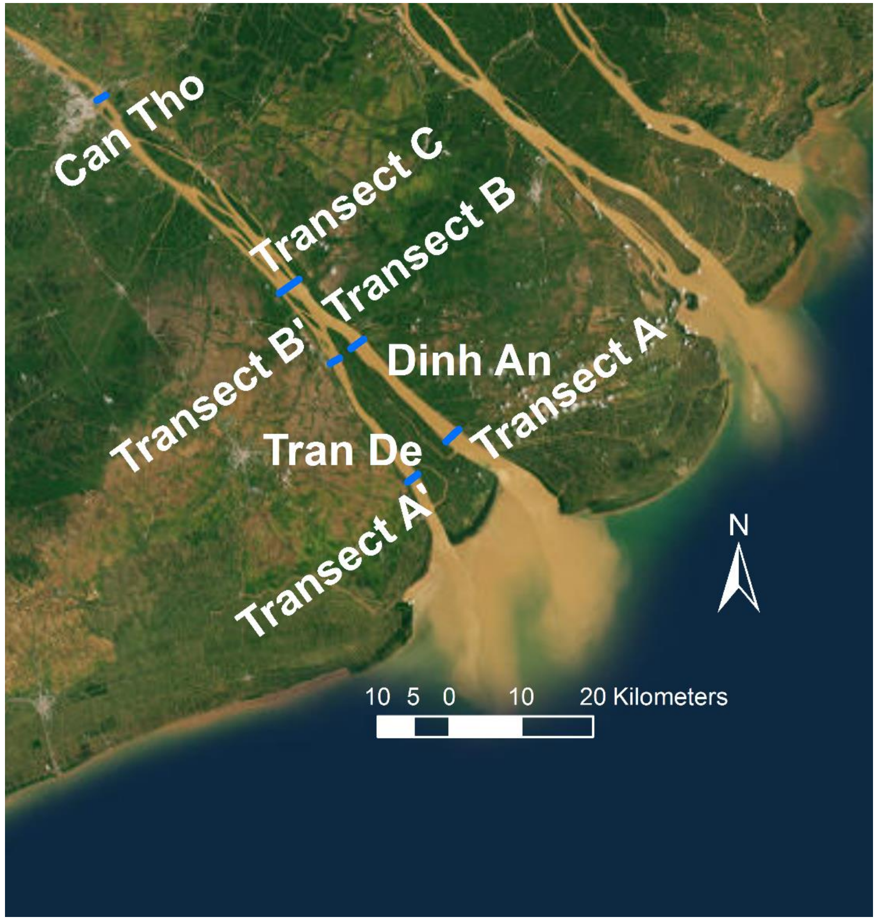
Data Collection



- 5 transects - occupied for 12.4 hour and 24.8 hour tidal periods



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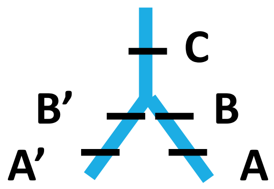

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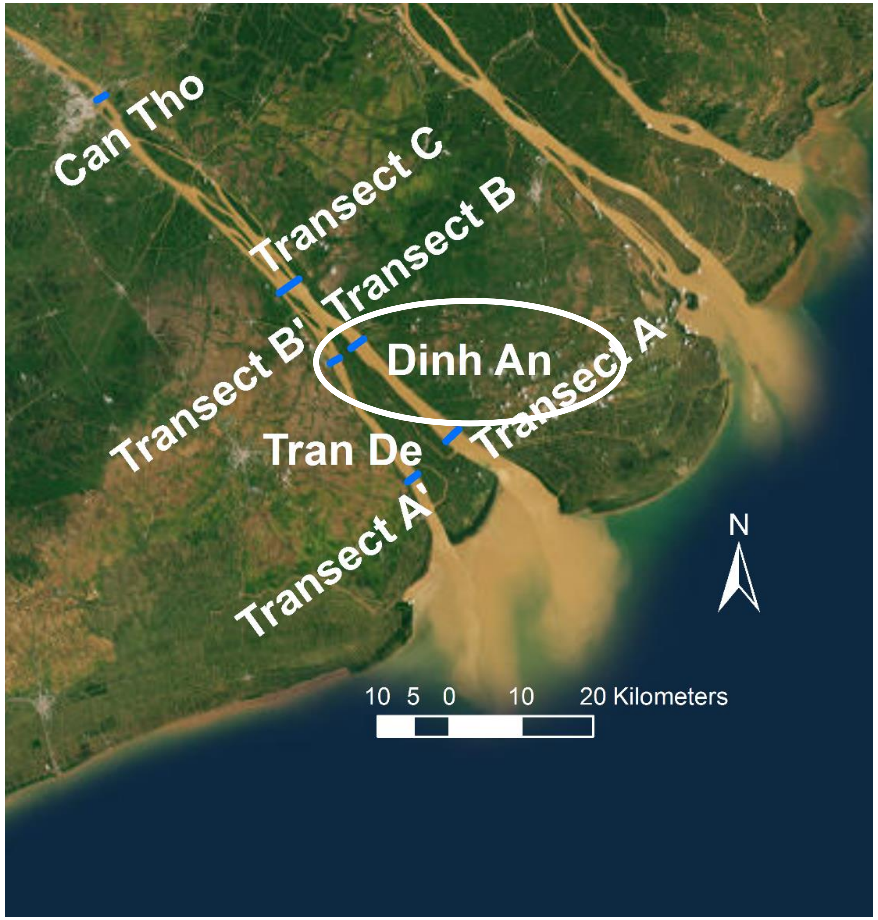
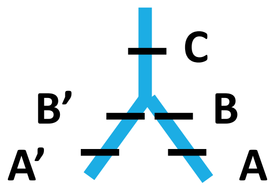
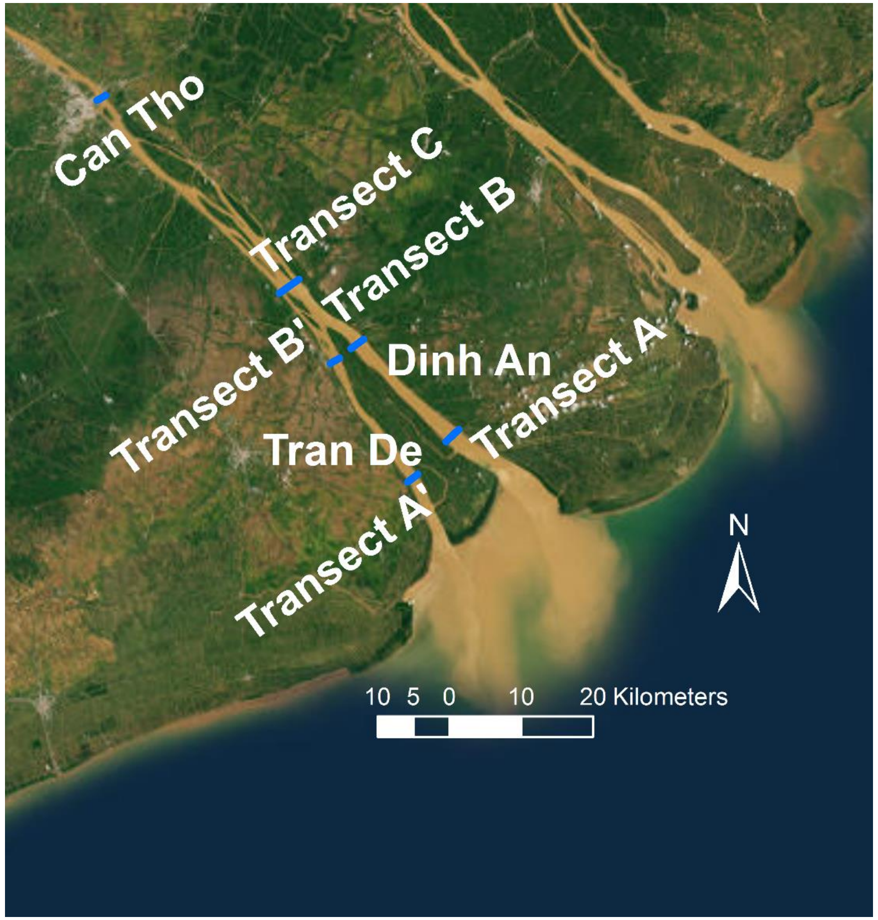




Data Collection

- 5 transects - occupied for 12.4 hour and 24.8 hour tidal periods
- Data types
  - Laser In-Situ Scattering Transmissometry (LISST)

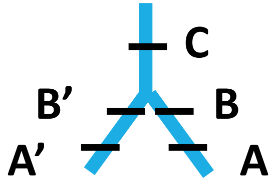


LISST Instrument

- Forward scattering laser diffraction
- Measurement range:

  1.9 µm – 381 µm
- Volume concentration measurement (µl/L)
- Averaged to fractional depths:

  0.1, 0.3, 0.5, 0.7, 0.9



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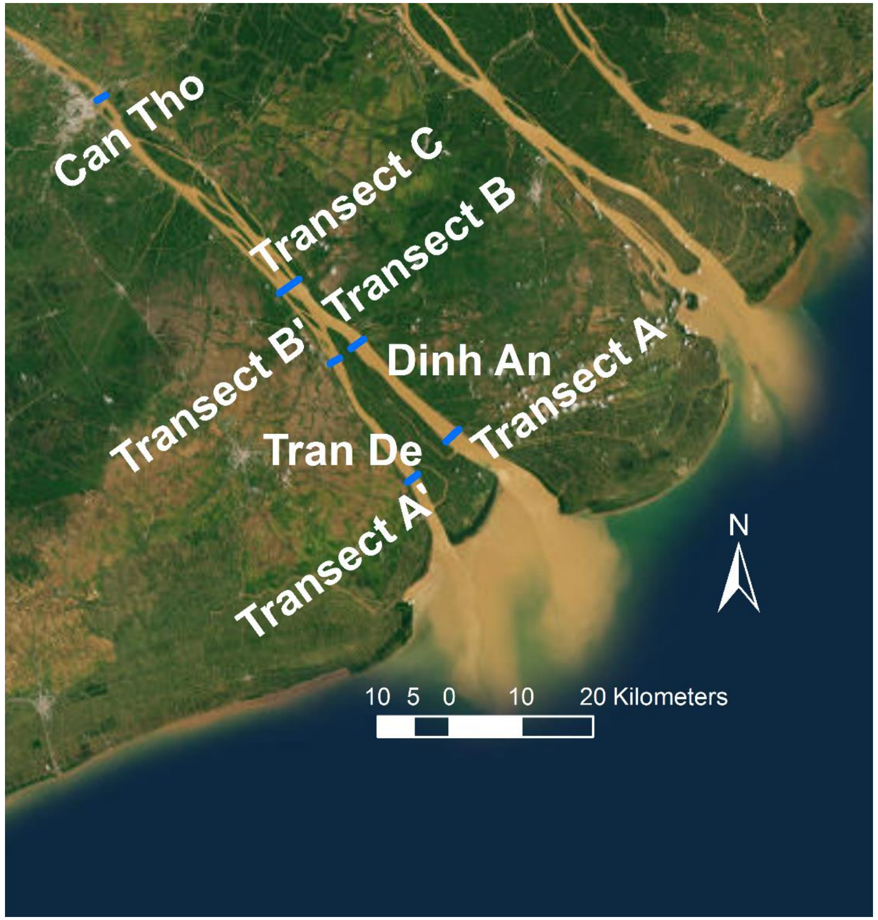

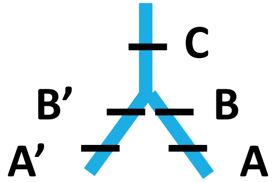

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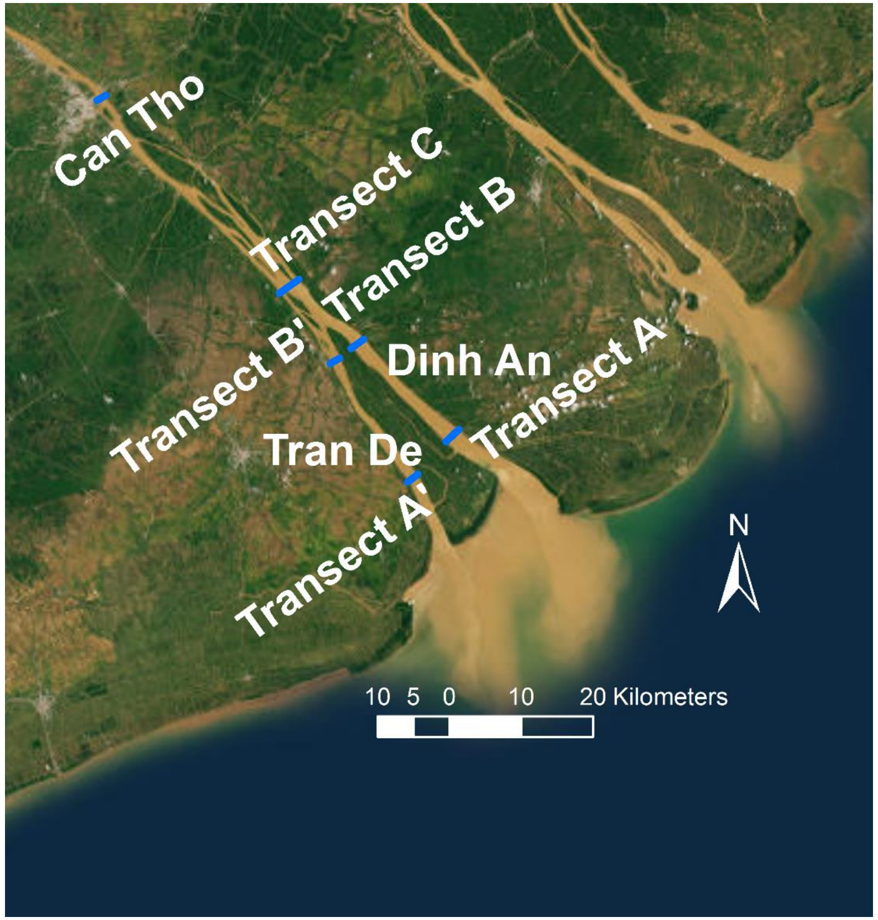

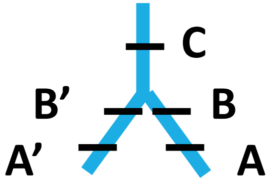

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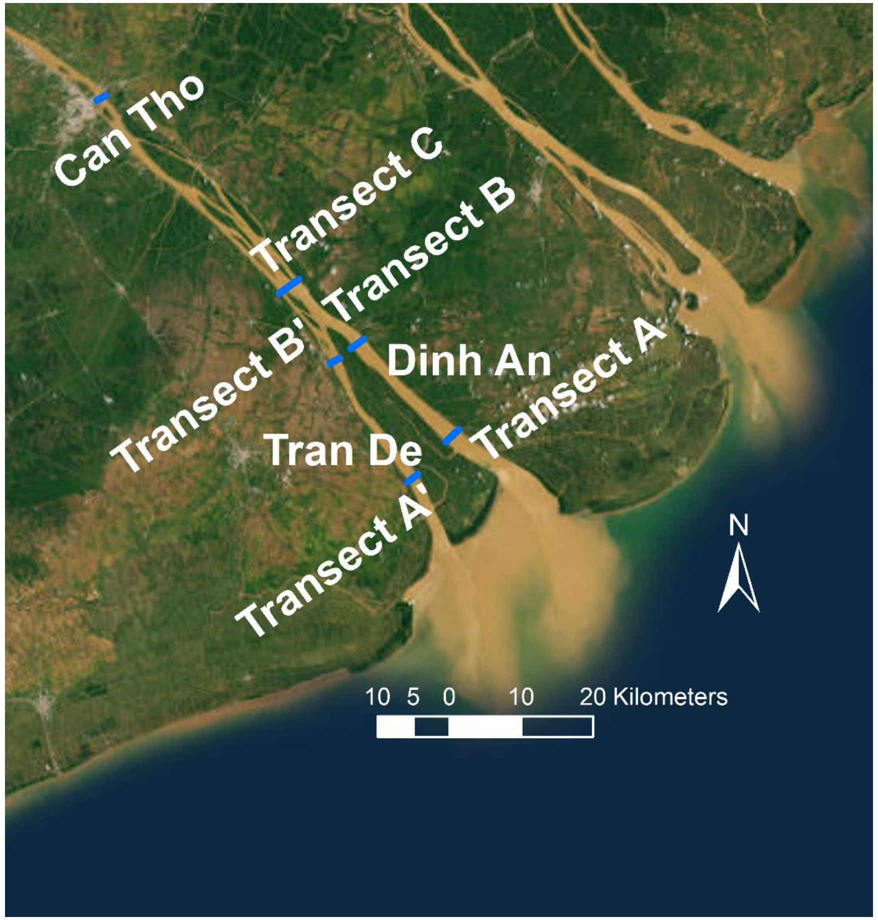
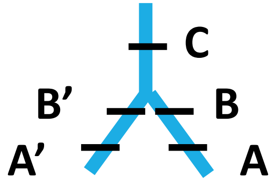
  - Multibeam bathymetry – bed elevation and bottom type





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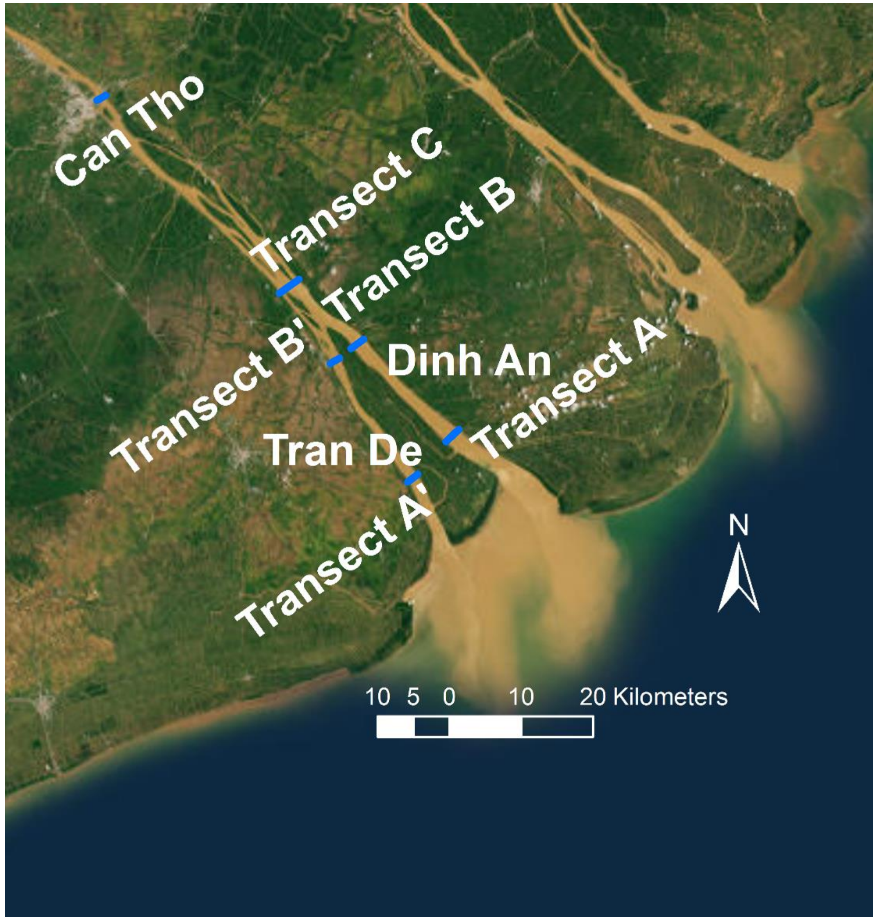
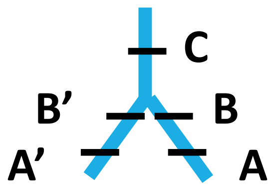
- High discharge and low discharge cruises





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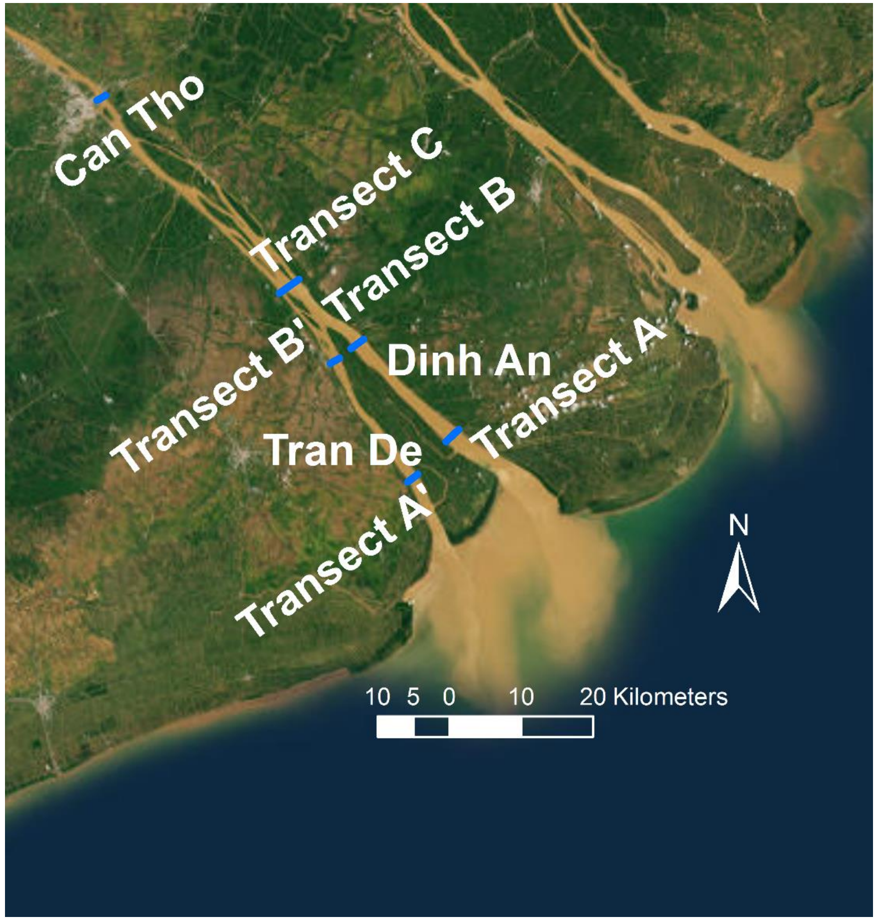
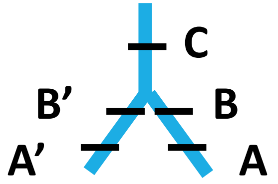
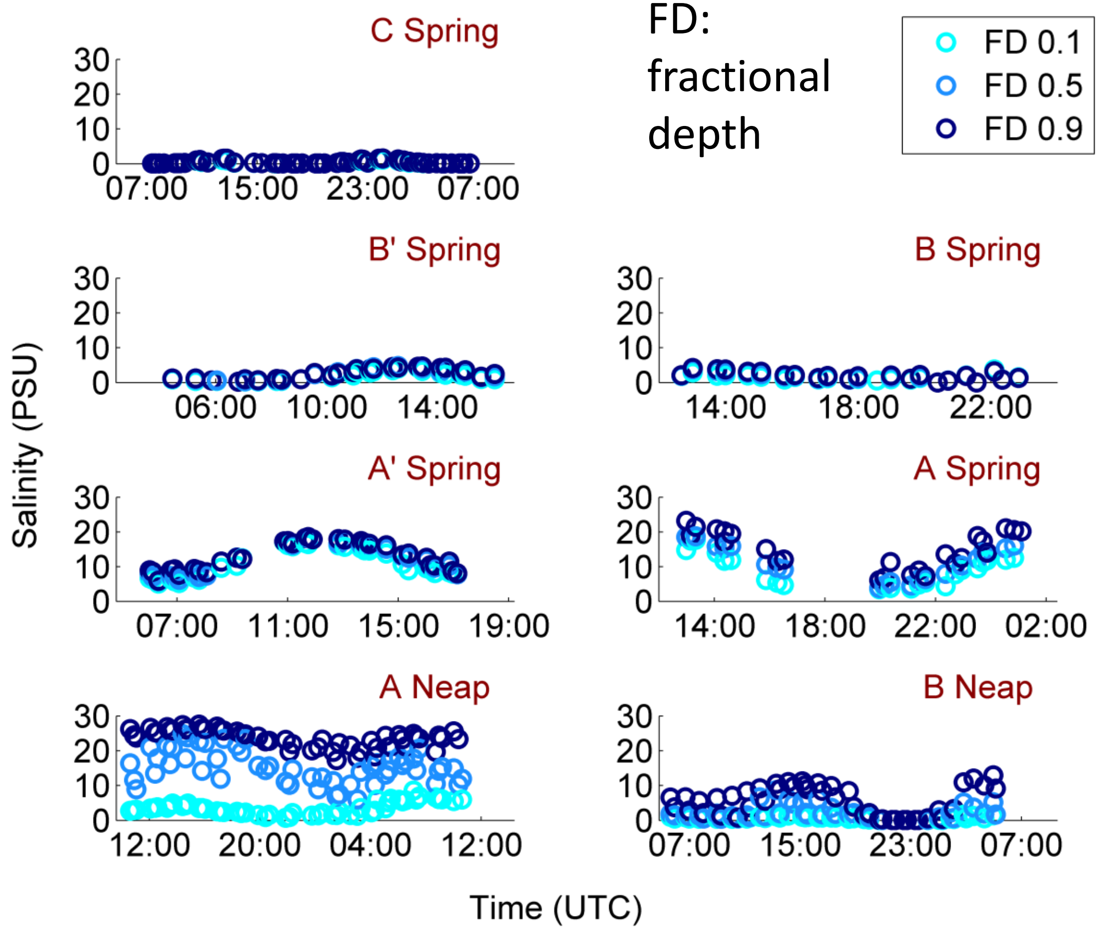




Low Q Salinity

- Transect C sees very little salinity (< 1.5 PSU)
- Transect B and B': 1- 4 PSU
- Transect A and A': 4-21 PSU



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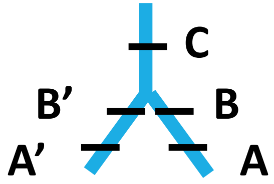
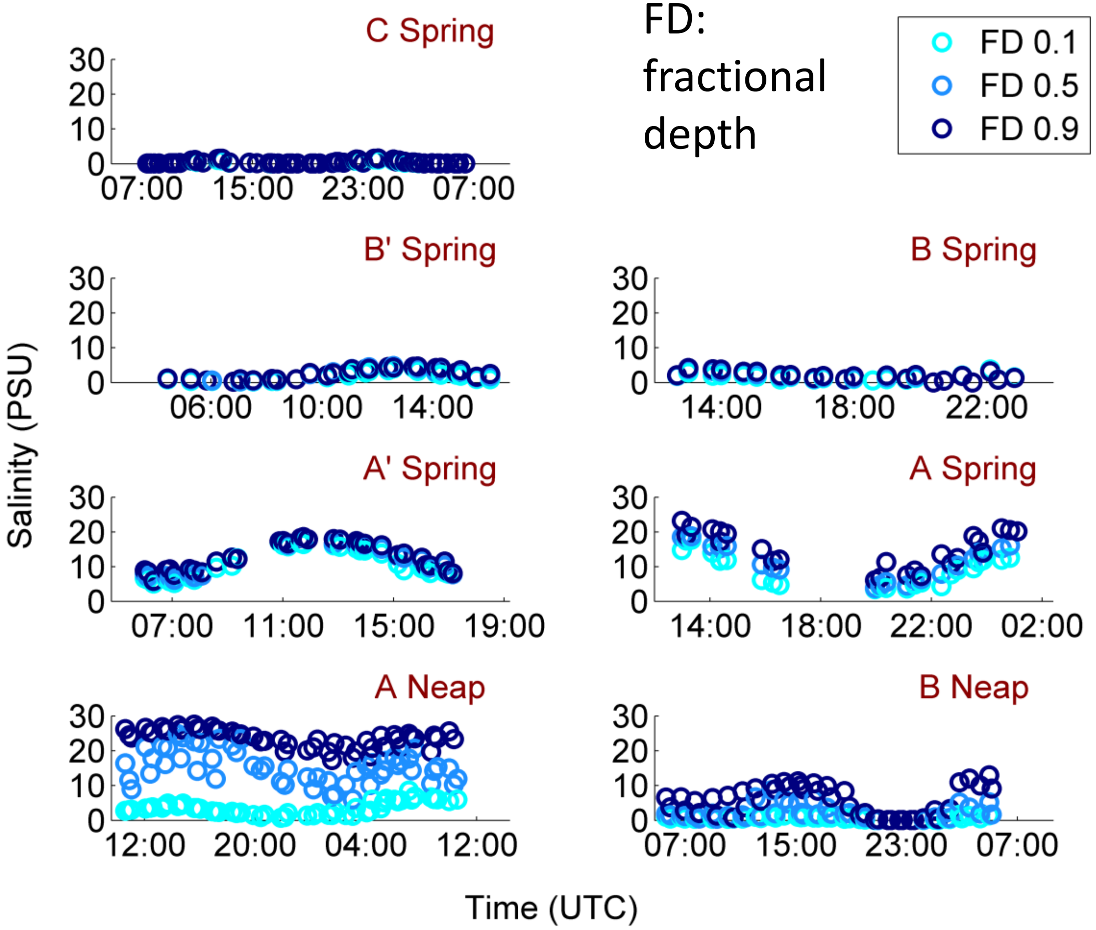
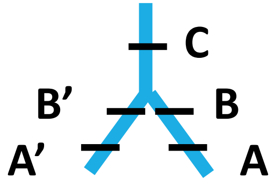


- Transect C sees very little salinity (< 1.5 PSU)
- Transect B and B’: 1- 4 PSU
- Transect A and A’: 4-21 PSU
- Neap tides
  - Less well mixed than spring tides
  - Have higher maximum salinities
  - 10 PSU at Transect B
  - 27 PSU at Transect A

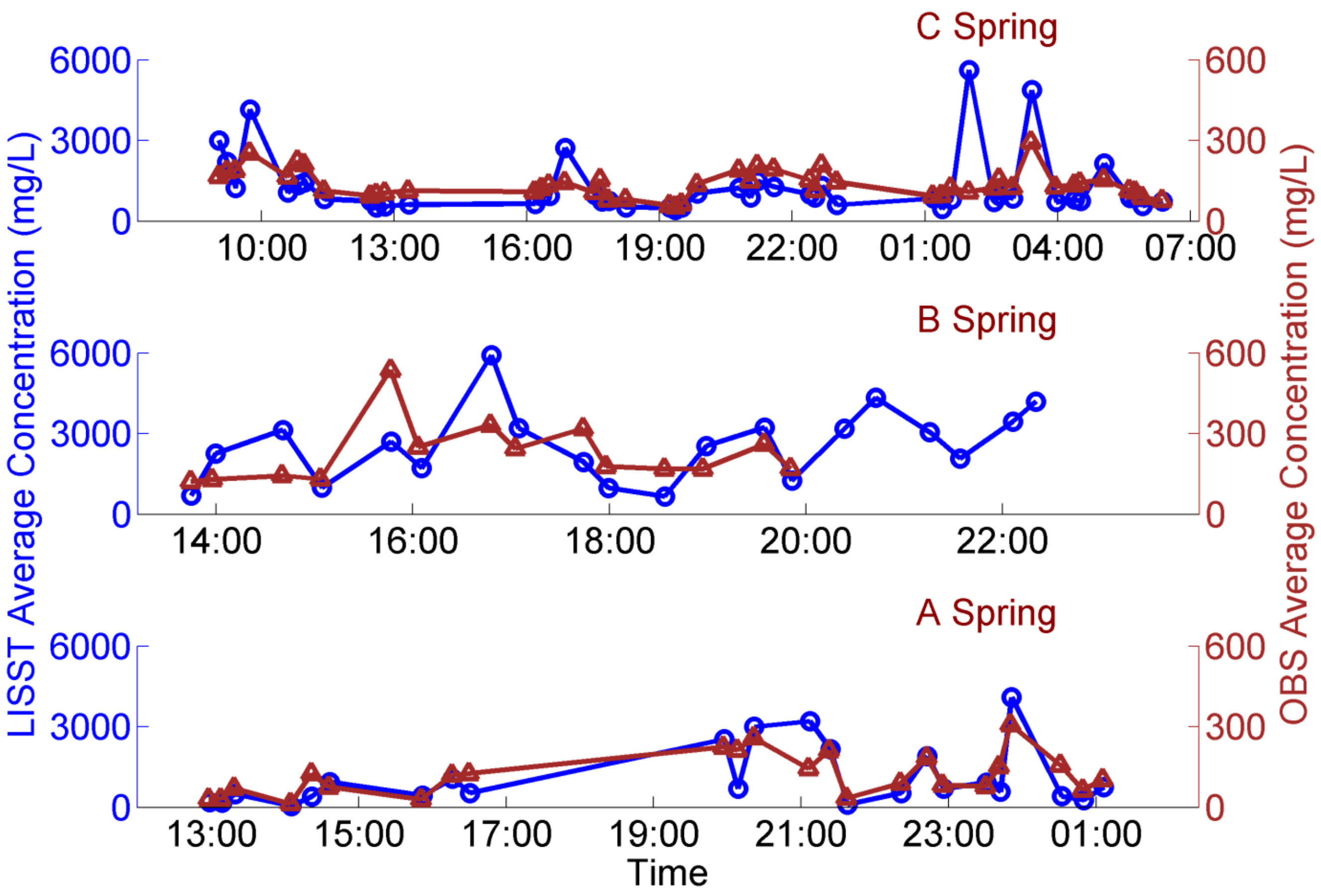


Low Q Suspended Sediment Concentration



- Same trends
- Different magnitudes

LISST mass concentration = volume concentration*2.65 g/cm^3



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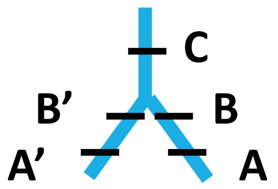
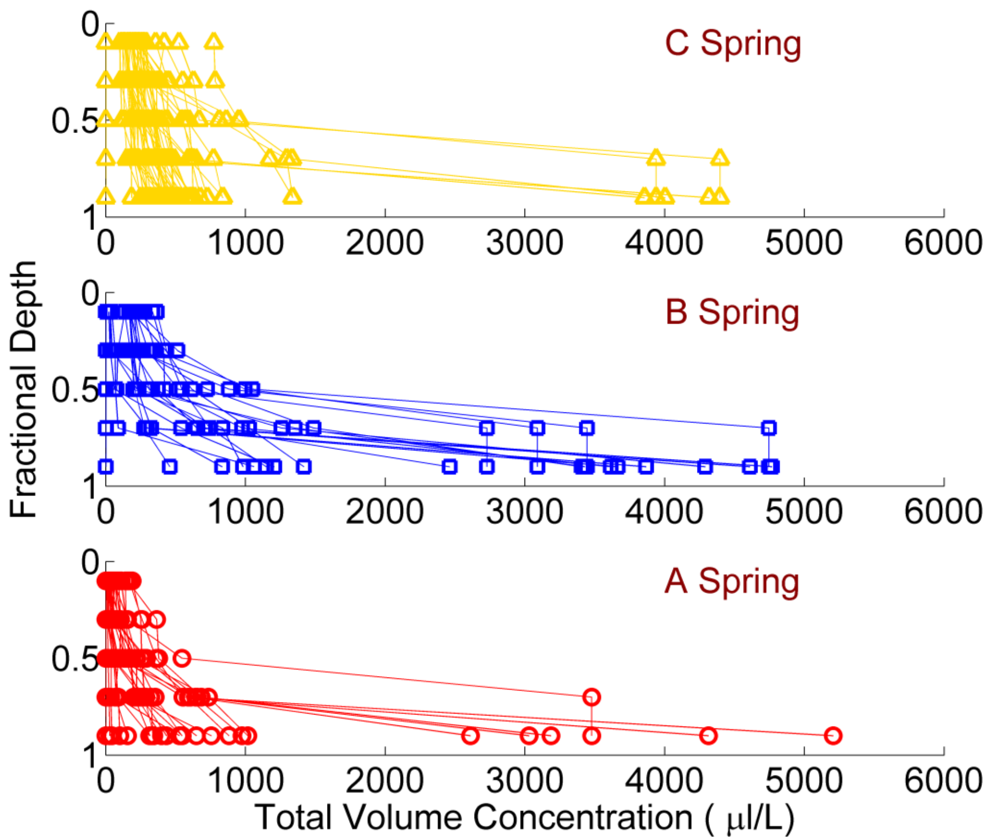
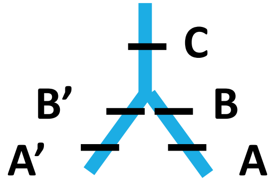
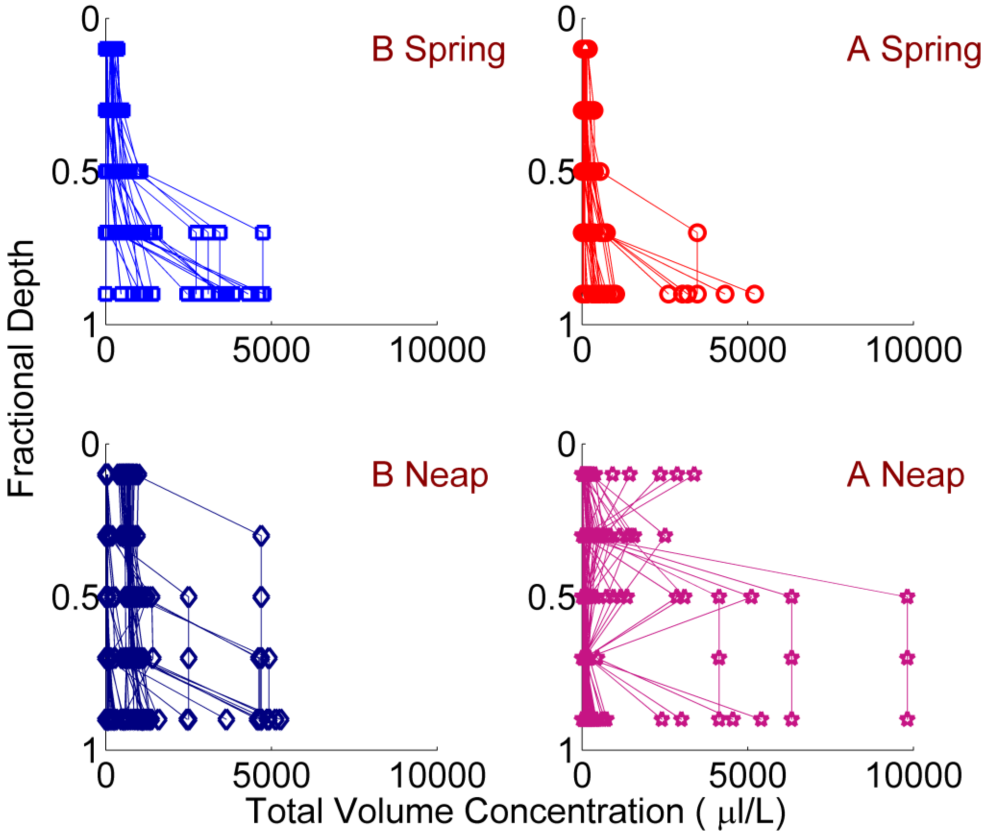




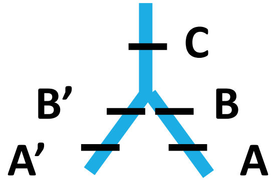
- Increasing concentration with depth

Low Q Suspended Sediment Concentration

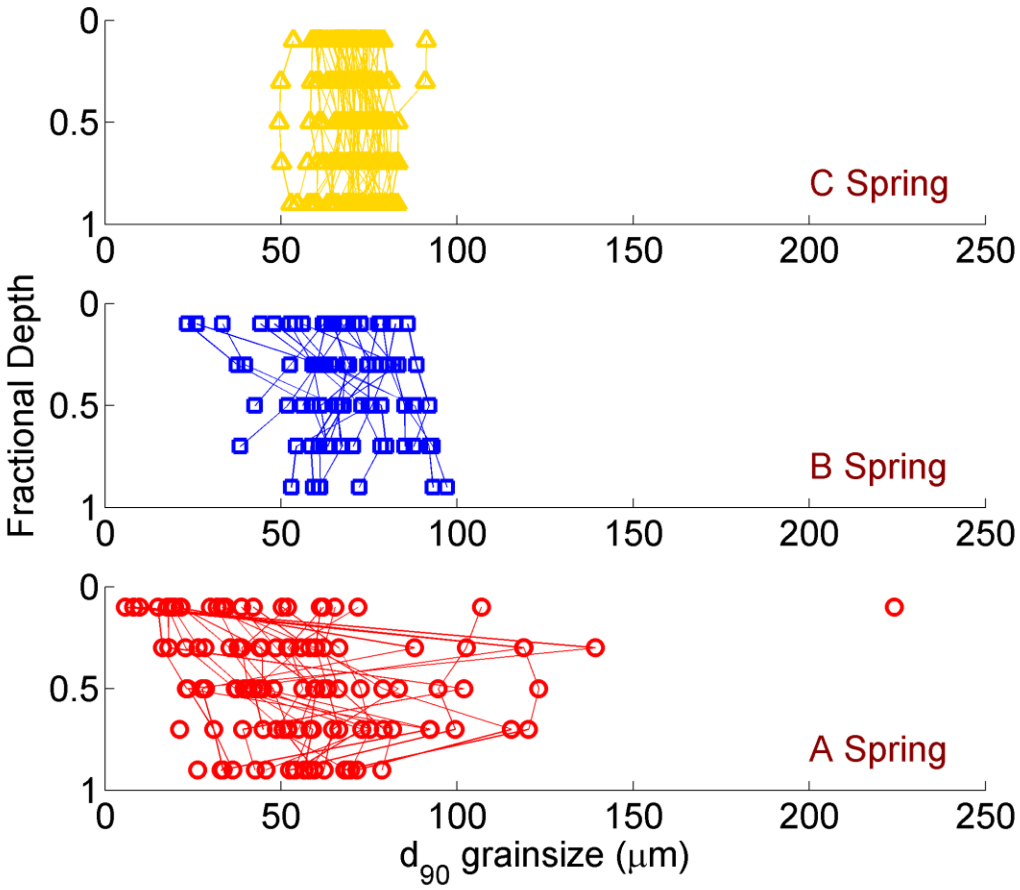




- Increasing concentration with depth
- Neap tides have greater suspended sediment concentrations.

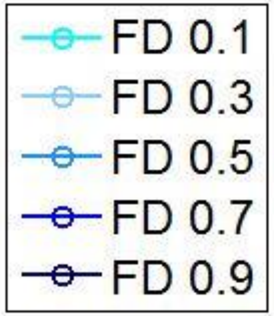


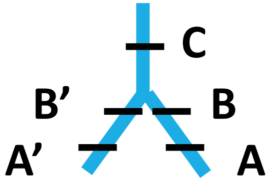
Low Q Suspended Sediment Grain Size

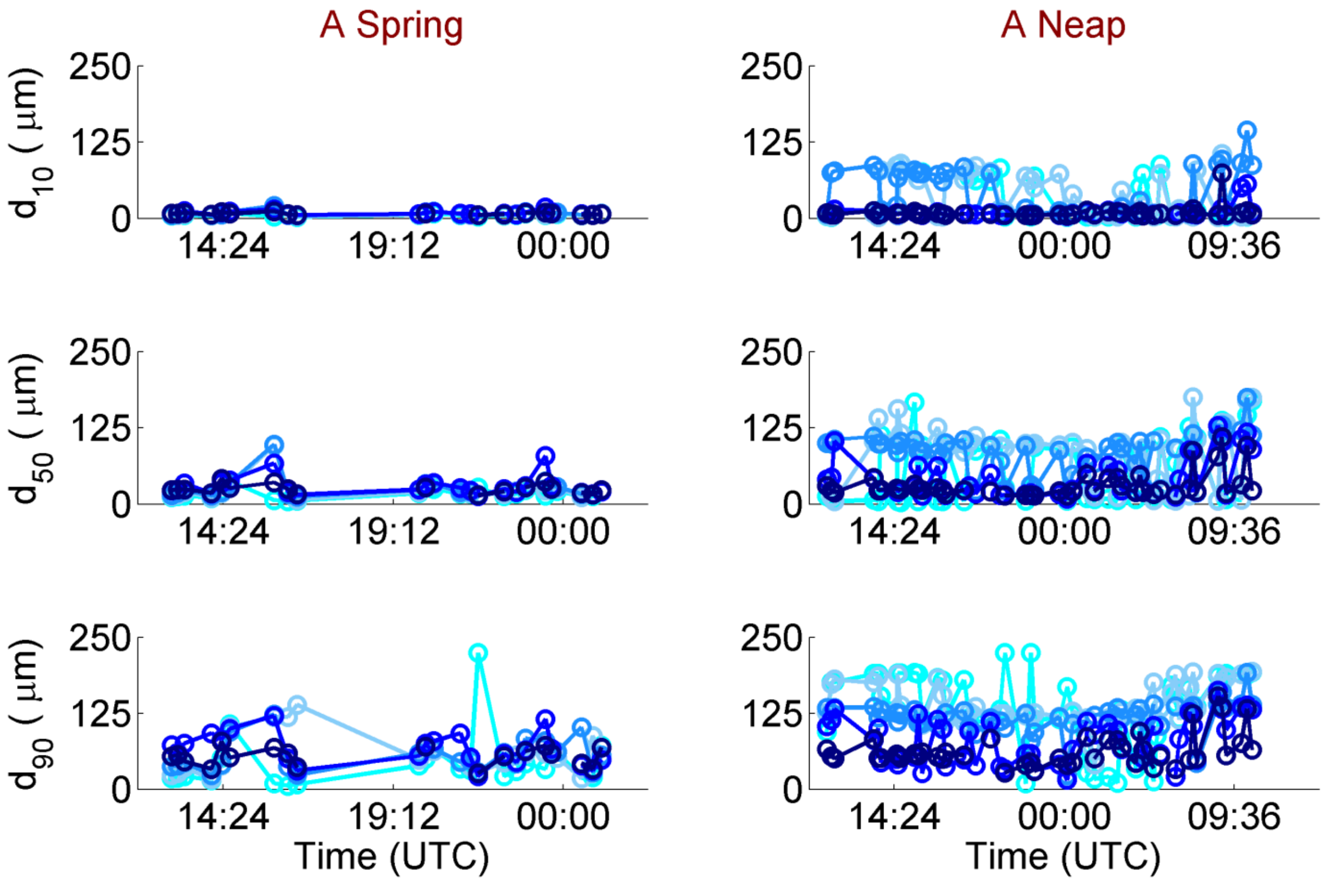


- Particle size increases with depth
- Large particles also found in the middle and upper water column

Low Q Suspended Sediment Grain Size

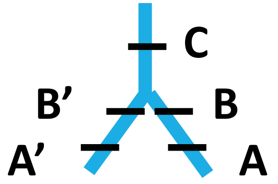


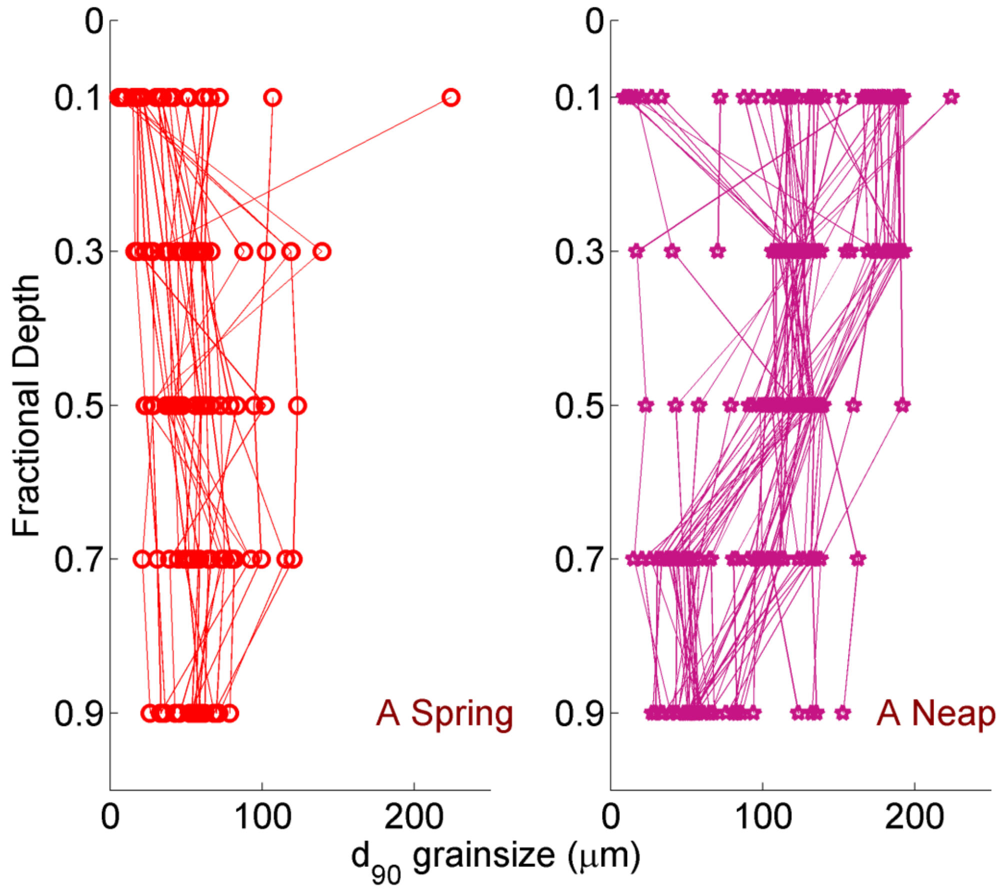




- Same transect
- Different tidal phase
- Spring and neap tides have different particle sizes
- Neap tides
    - Large particles throughout the water column

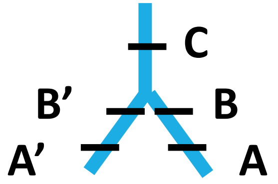
Low Q Suspended Sediment Grain Size

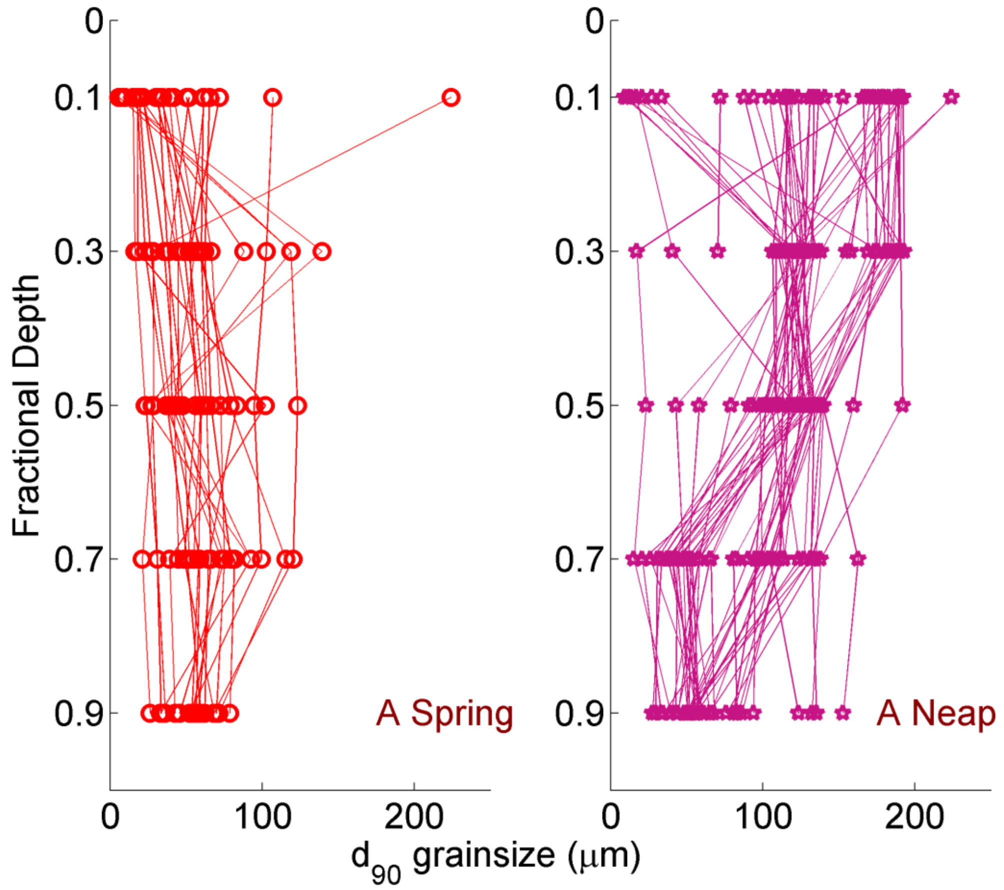




- Particle size is smaller at the bottom of the water column
- Potentially an effect of floc break up or settling of the largest flocs

Low Q Suspended Sediment Grain Size





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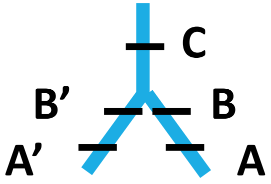
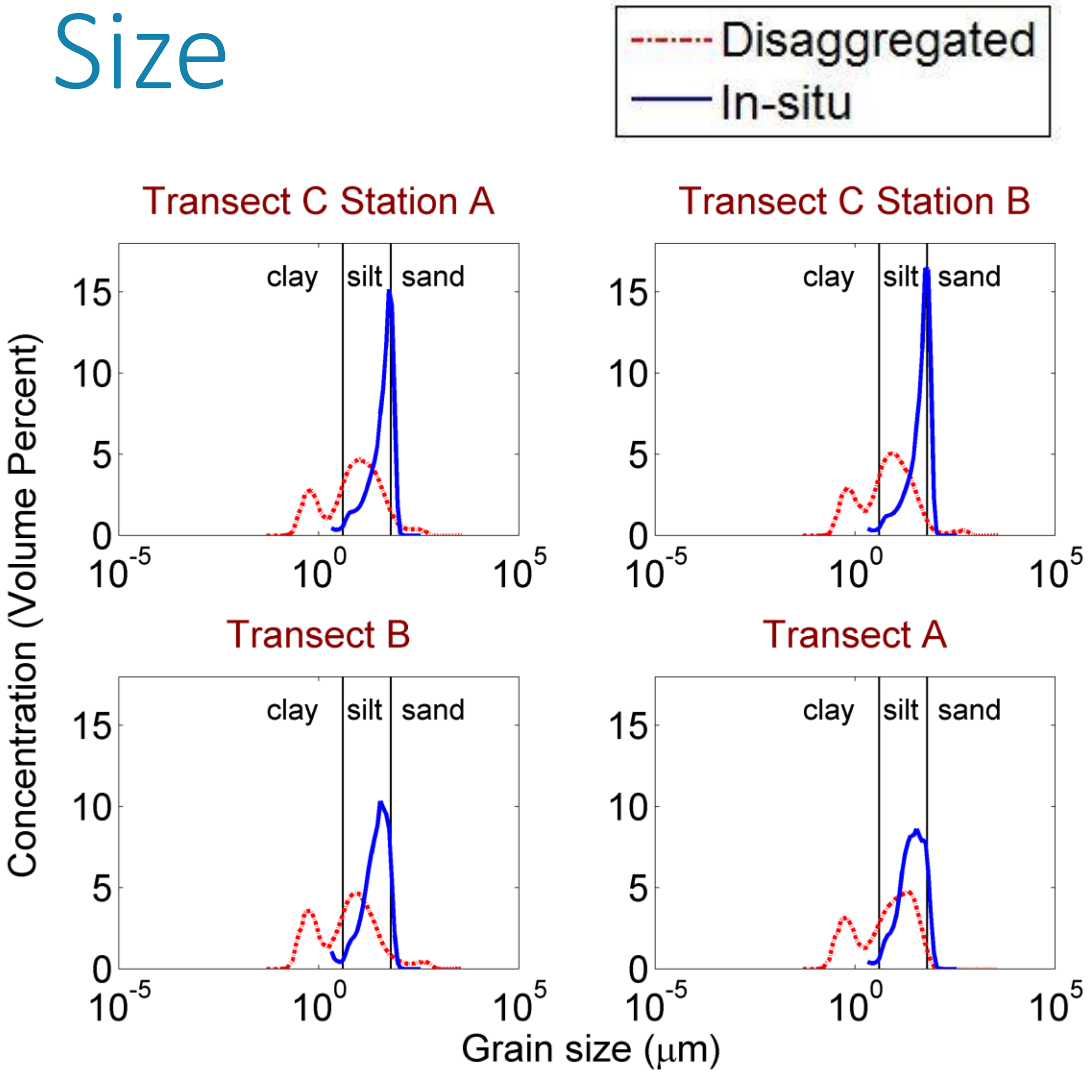
In-situ Grain Size vs Disaggregated Grain Size



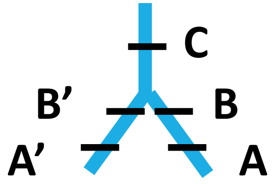


- LISST provides in-situ particle size
- Malvern Mastersizer 3000 provides disaggregated grain size

- In-situ particles = silt and sand range
- Disaggregated grains = clay and silt

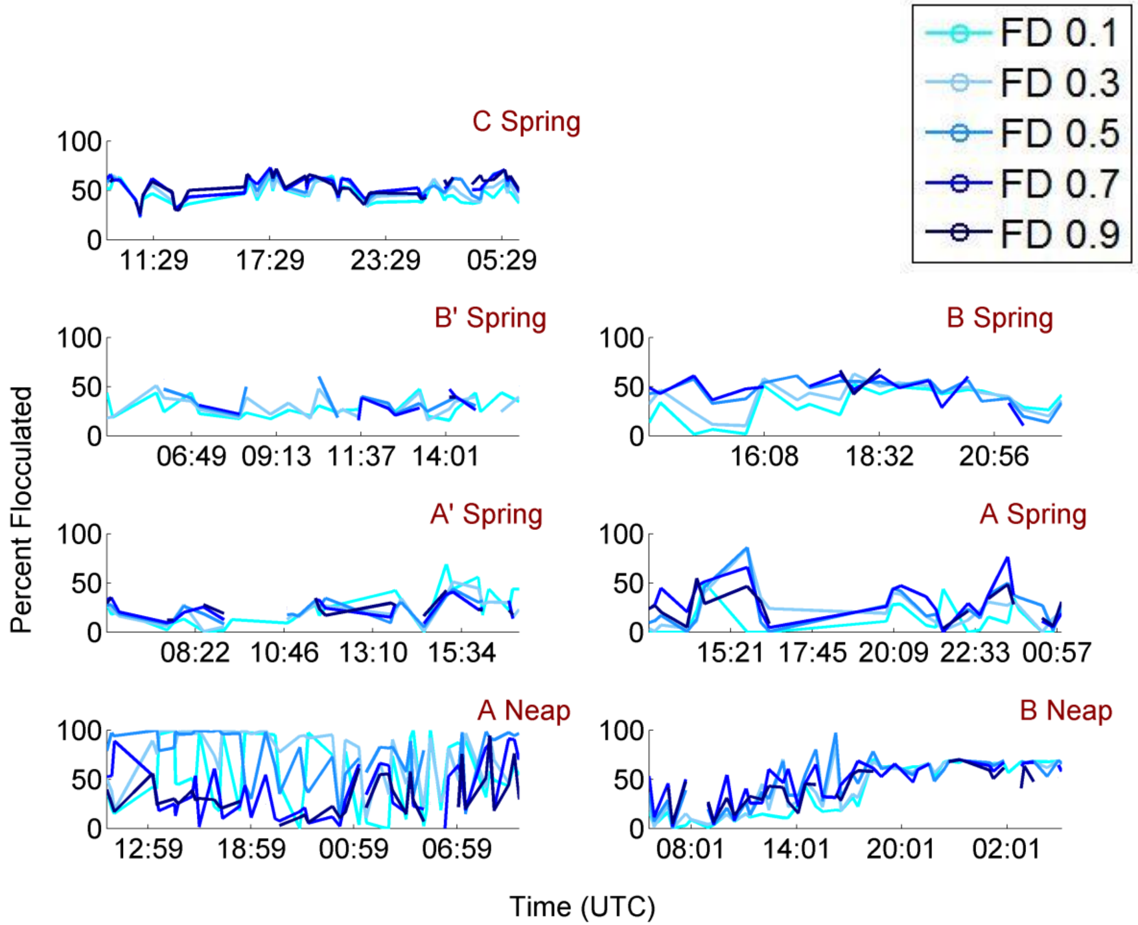
	Percent change in particle size after disaggregation
d_{10}	-179
d_{50}	-134
d_{90}	-54

Percent of Flocculated Particles

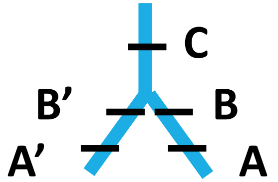


- ~40 µm threshold (McLachlan et al. 2017)
- Flocs are present at every transect

- ~50% of the sediment by volume in the lower Song Hau is flocculated
- Higher percentage is flocculated during neap tides



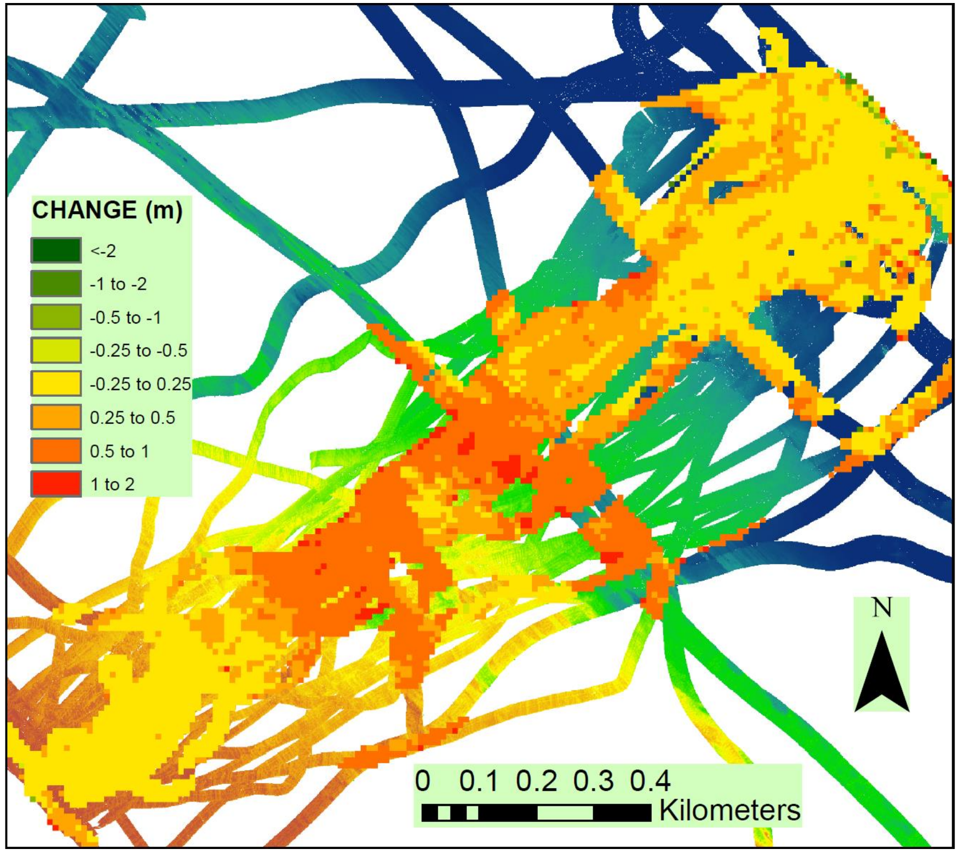
Implications for Sediment Transport and Trapping in the Mekong River



- Bed shoaling during low Q (multibeam surveys of elevation and bed type)
  - Deposition of soft mud (0.25 to 1 m thick)
  - Covers sand beds (Allison et al. 2017)

- Low (or zero) sand concentrations from water samples at low Q (Stephens et al. 2017)

- Salinity stratification shields against resuspension at low Q (McLachlan et al. 2017)



Bathymetric Change (m) Transect B 2014-2015 (Allison et al. 2017)

Conclusions

- Flocculation affects the seasonality of sediment export to the ocean in the Mekong River
  - Low Q: promotes the trapping of fine sediment and the seasonal shutdown of sand transport
  - High Q: fine sediment is exported to the ocean
- Salinity increases floc size and settling rate
  - Transect A neap → largest particle sizes
- Neap tide conditions enhance flocculation
  - Greater mixing of sediment aggregates through the water column
  - Larger flocs

QUESTIONS?

- Paper forthcoming:
  - *Suspended sediment character in the tidal Mekong River: observations from LISST profiling*
  - Diana R. Di Leonardo, Mead Allison, Robin McLachlan, Andrea Ogston
- Thank you to:
- Office of Naval Research for funding this work, Award Number: N00014-14-1-0145
- Field team from Tulane University, University of Washington, and Vietnam National University (Ho Chi Minh City) for their tireless data collection efforts

Tulane University

THE WATER INSTITUTE OF THE GULF

SCHOOL OF OCEANOGRAPHY
UNIVERSITY OF WASHINGTON

Office of Naval Research
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Science & Technology

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