

HORIBA - SEQUOIA JOINT WEBINAR

**I. Grain size distribution and  
sediment flux structure in a river  
II. Sediments in Hydro - Turbine**

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# Laser Diffraction in Rivers/Hydropower

**Sequoia Scientific, Inc. (Bellevue, WA) are makers of LISST-series field instruments.**

**These are used in coasts, ports, harbors, oceans, rivers, and in industry.**

[LISST is a trademark of Sequoia Scientific, Inc.]

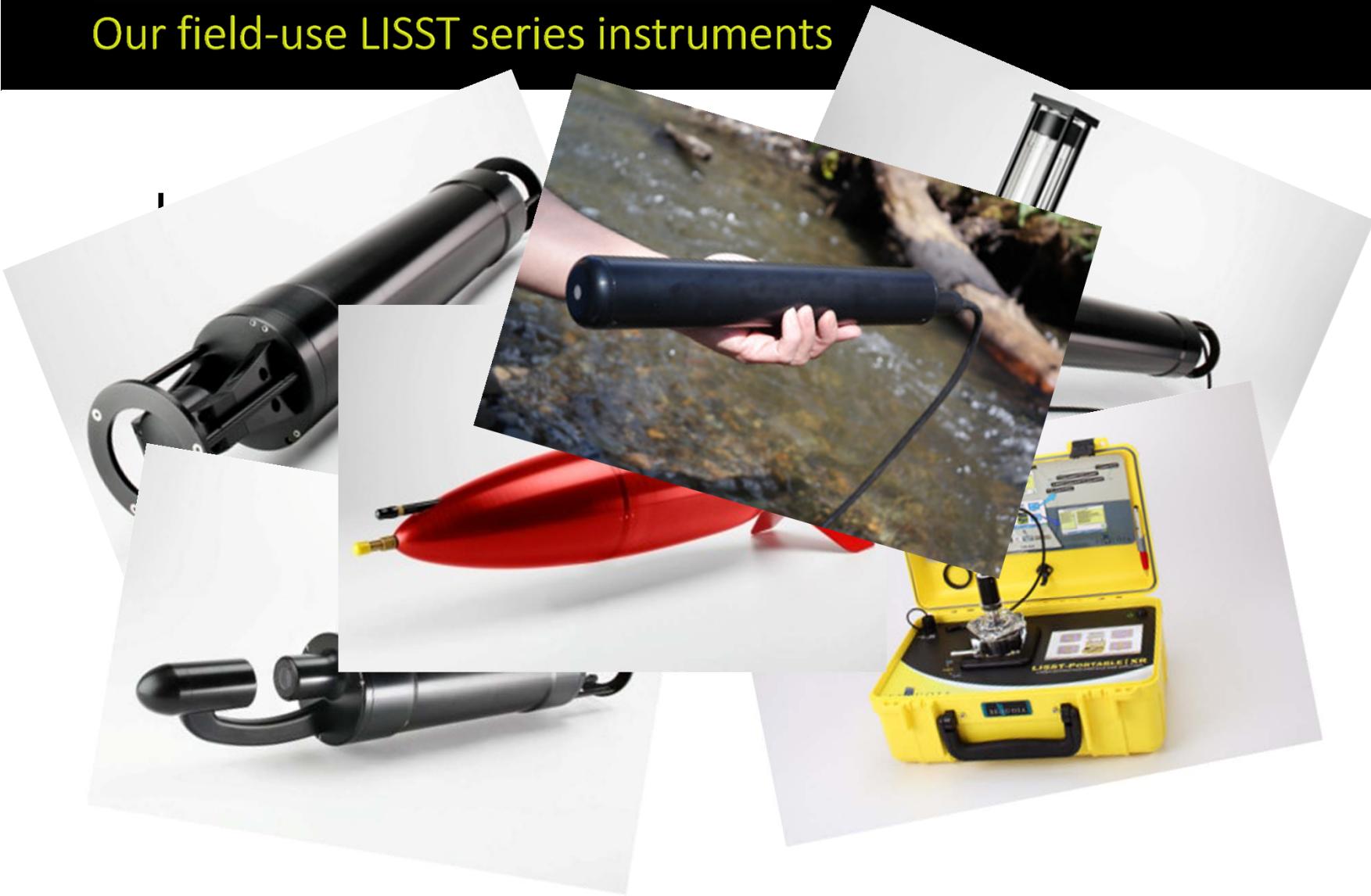
# Some Applications



Our instruments at 1. Grand Canyon USA, 2. Three Gorges Dam, China; 3. Venice lagoon; 4. Deepwater Horizon oil spill monitoring; 5. Japan Fukushima monitoring; and 6. Danube in Hungary.

# Overview

Our field-use LISST series instruments



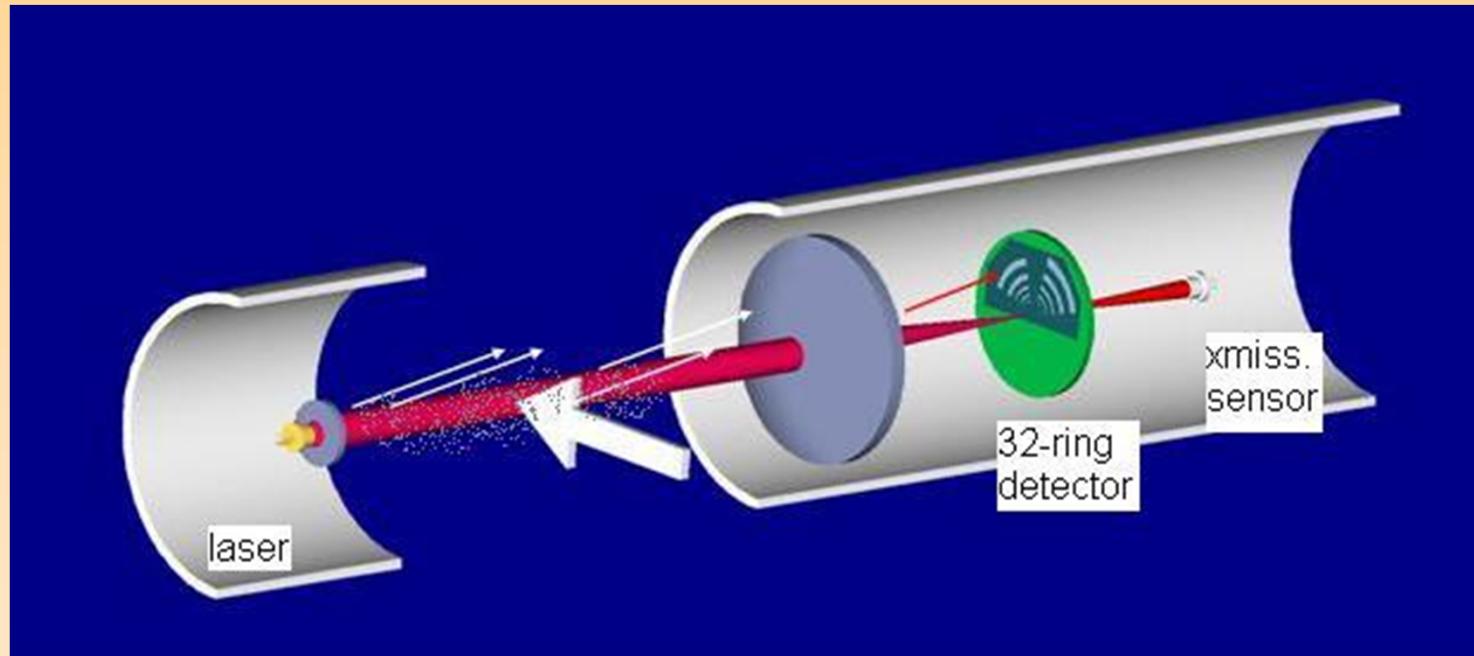
# I – Sediments in a River Column

The LISST-SL™ instrument is used to study Velocity, turbidity, sediment concentration and particle size distribution. We find some remarkable results.

[LISST is a trademark of Sequoia Scientific, Inc.]

(Data courtesy of Chris Curran and Raegan Huffman, USGS Tacoma, WA)

# Core Technology – Laser Diffraction



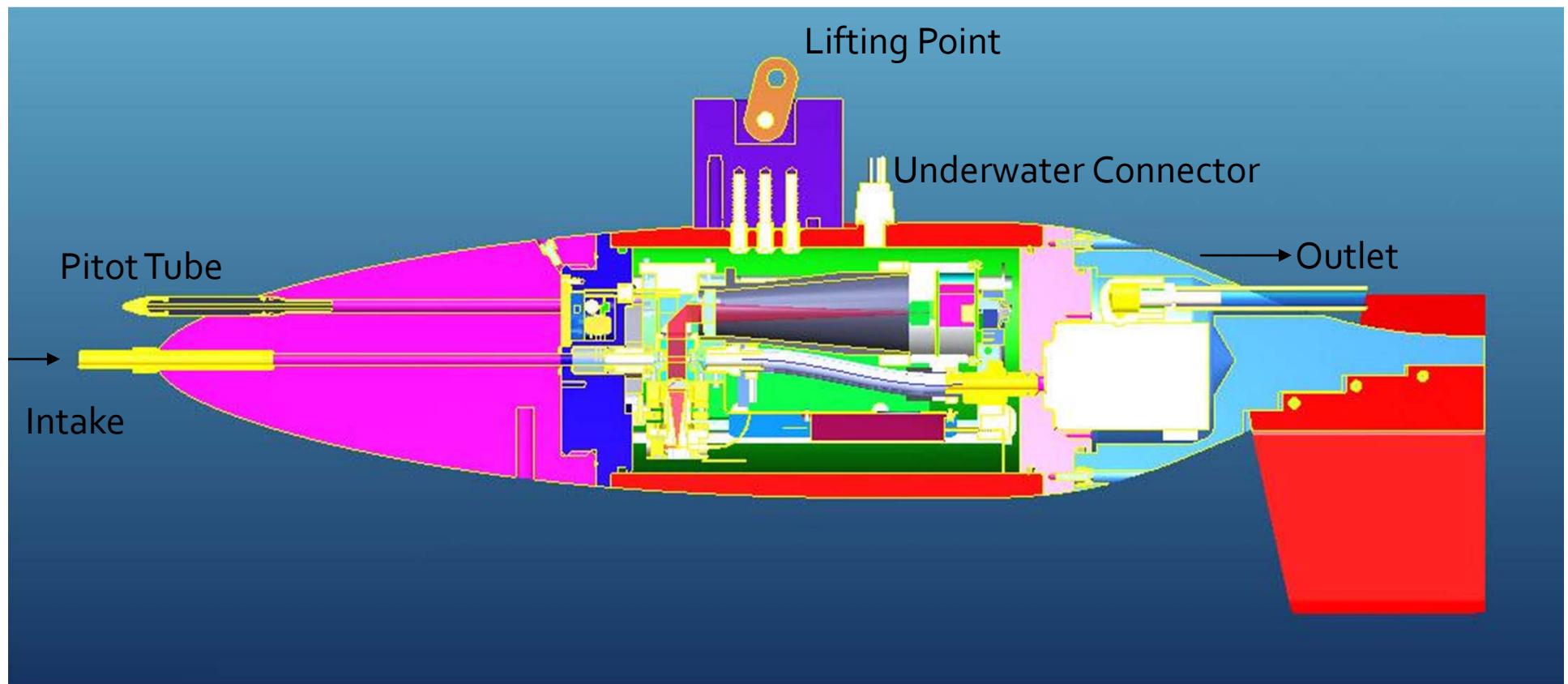
Measure:

- Multi-angle scattering;
- Optical Transmission

Derive:

- Particle Size Distribution
- Concentration

# I- LISST-SL – isokinetic!



# Prior Technology - Samplers

- Fish-shaped samplers
- Contained a bottle
- Sample analyzed in lab

P-61 sampler



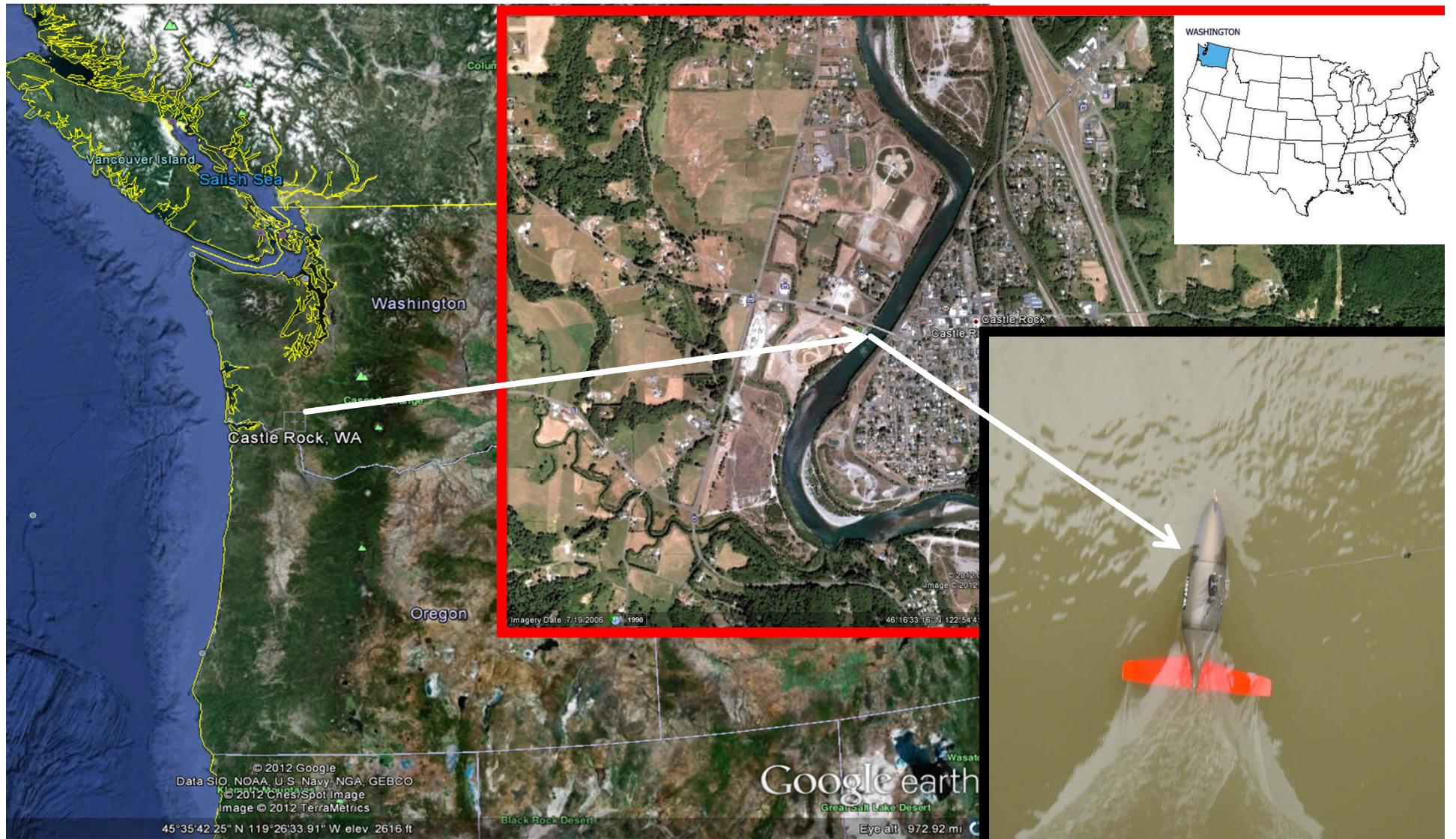
# Multi-parameter Data

- Depth
- Optical Transmission
- Velocity (from Pitot tube)
- Particle Size Distribution
- Concentration
- Water Temperature
- Pump control, and
- State of Battery

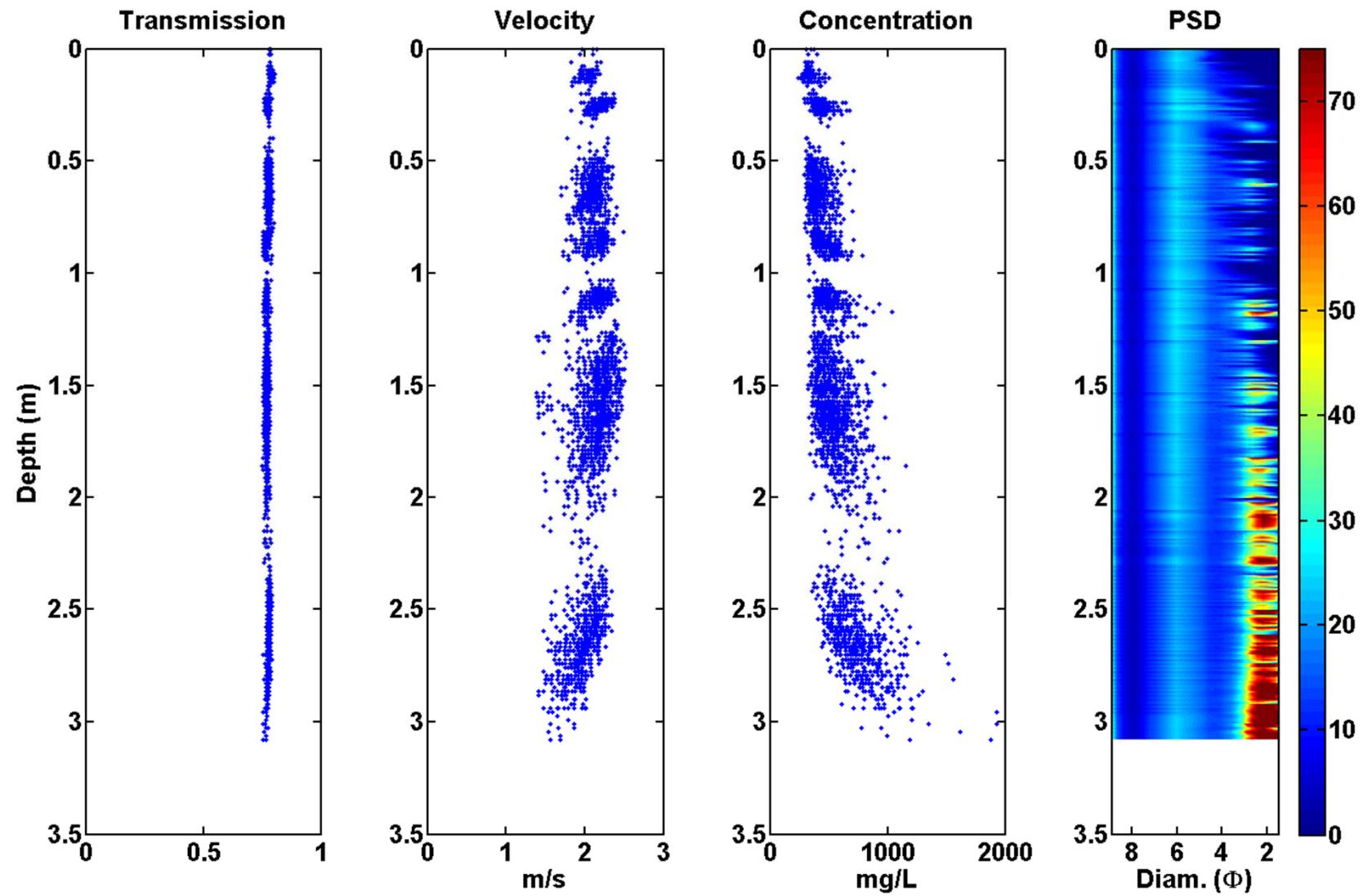
# I - LISST-SL – isokinetic!



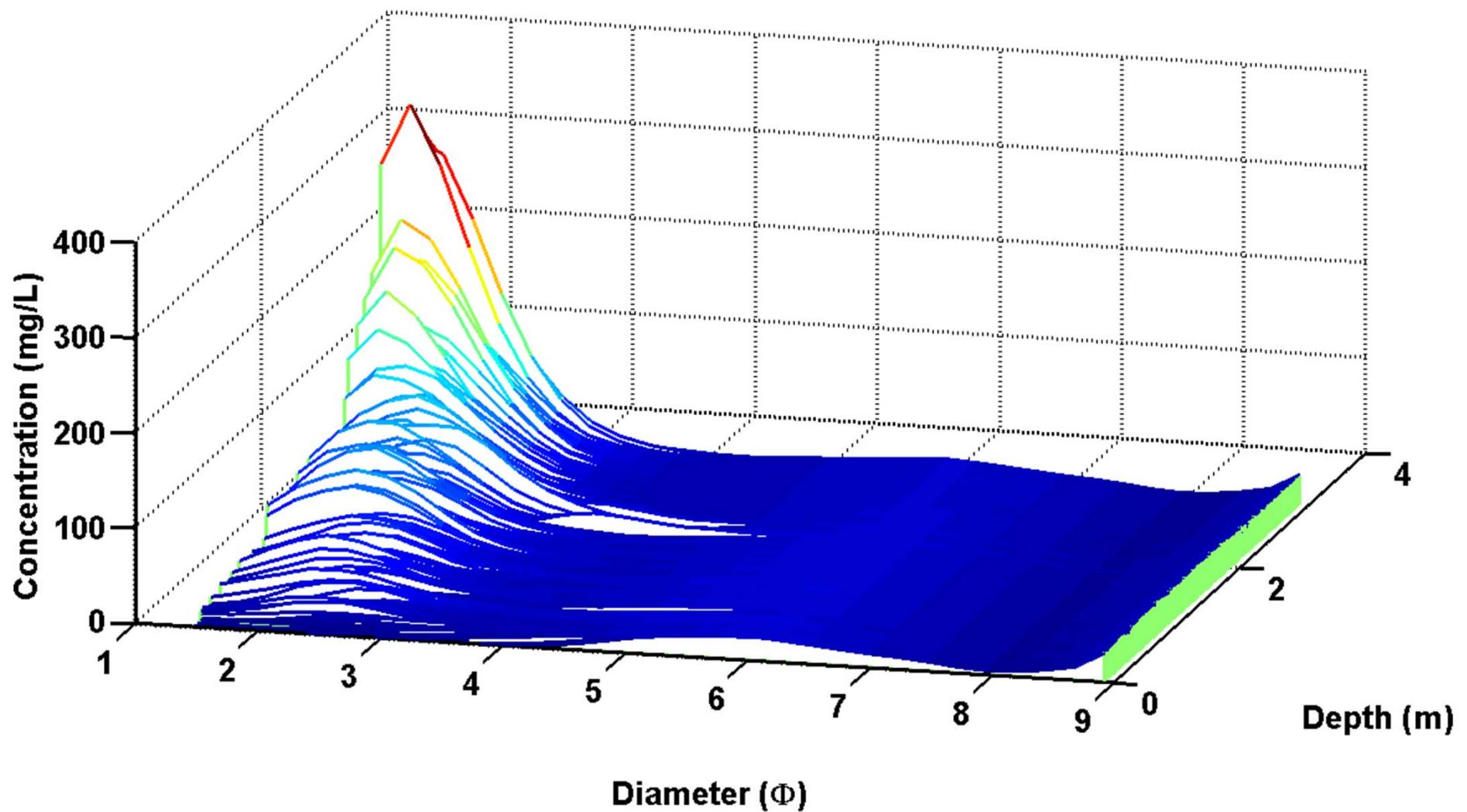
# I - Field data: March 2011



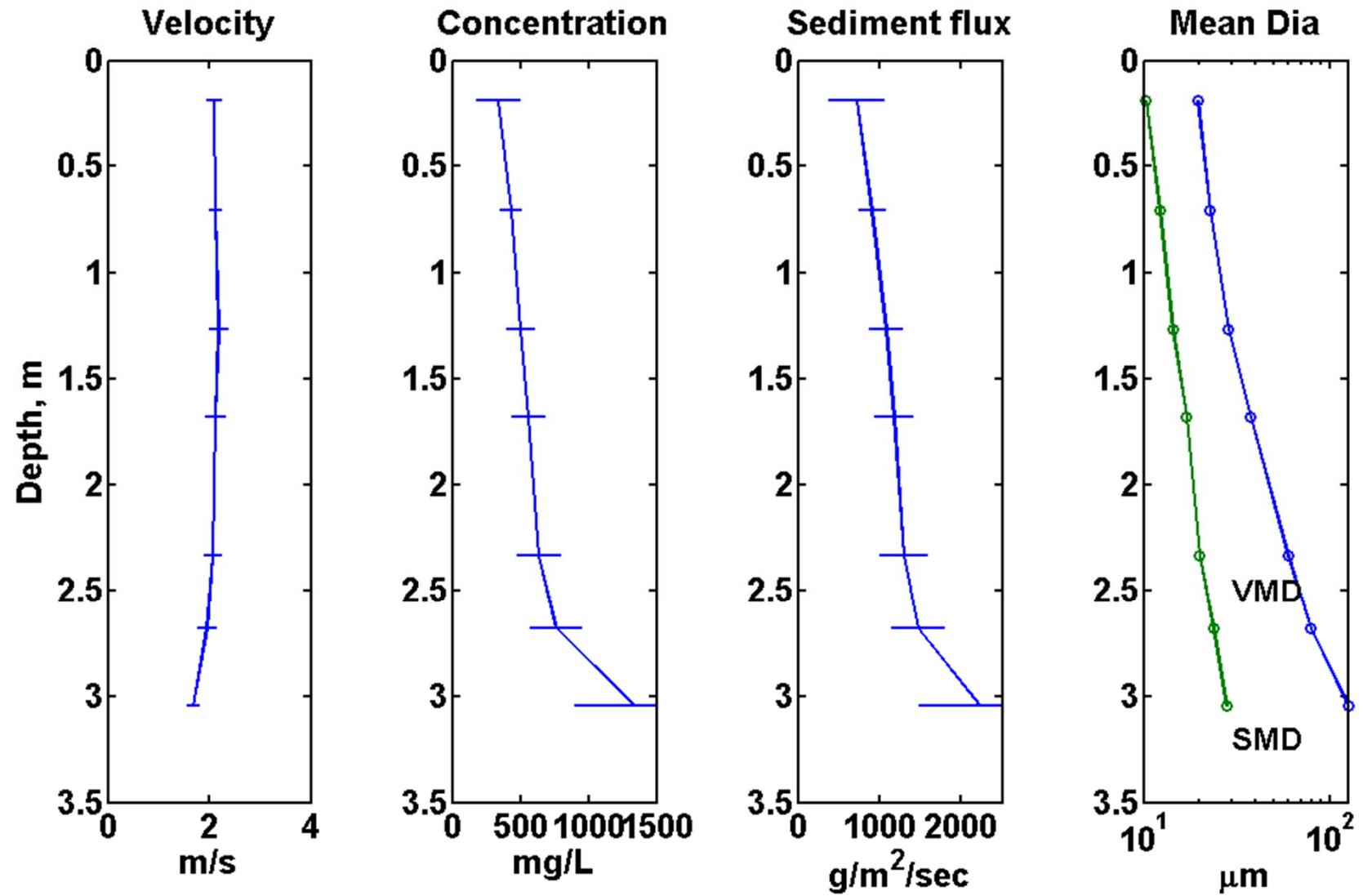
# I - All data, n=3551, < 1 day



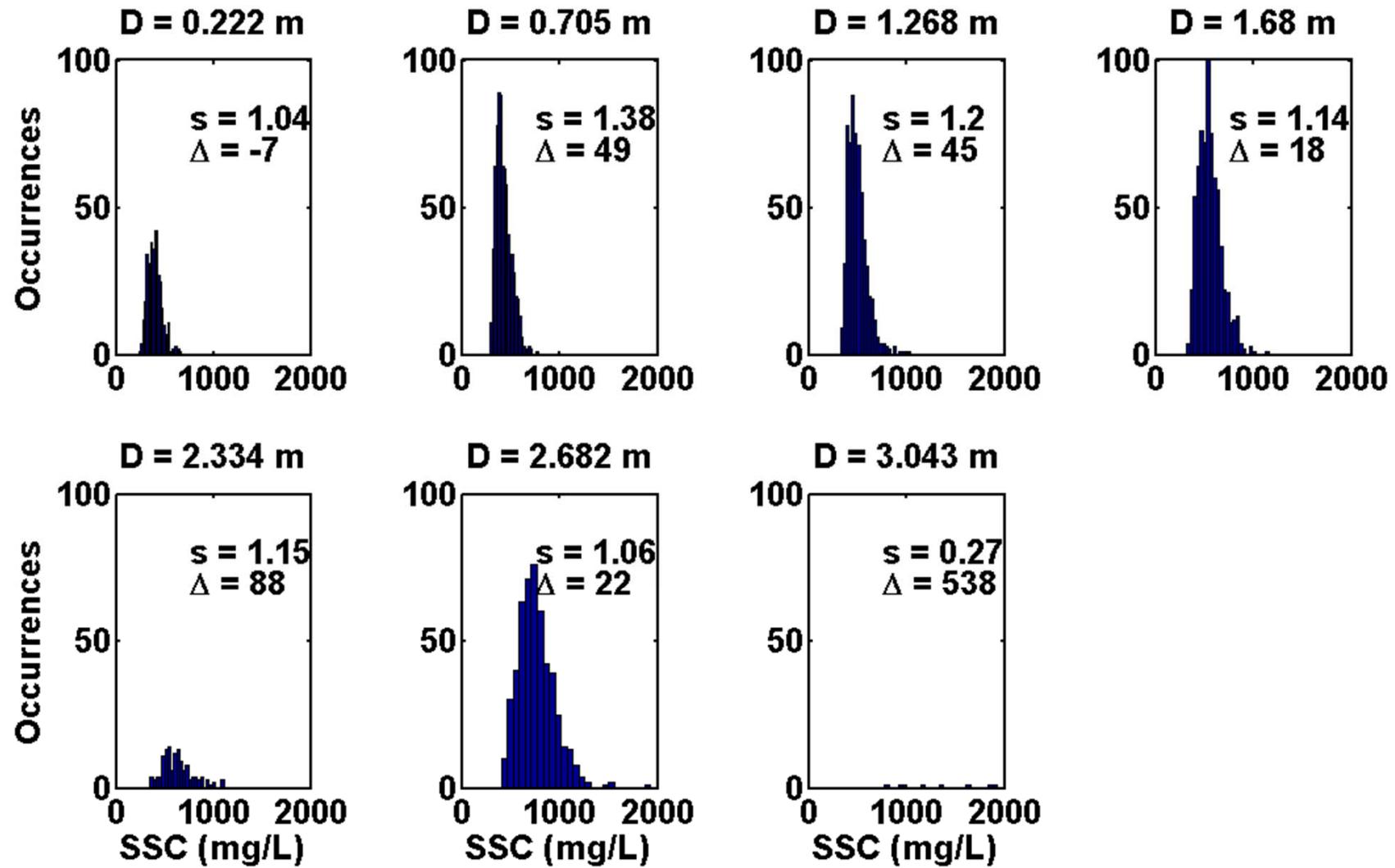
# I - Size spectra vs depth



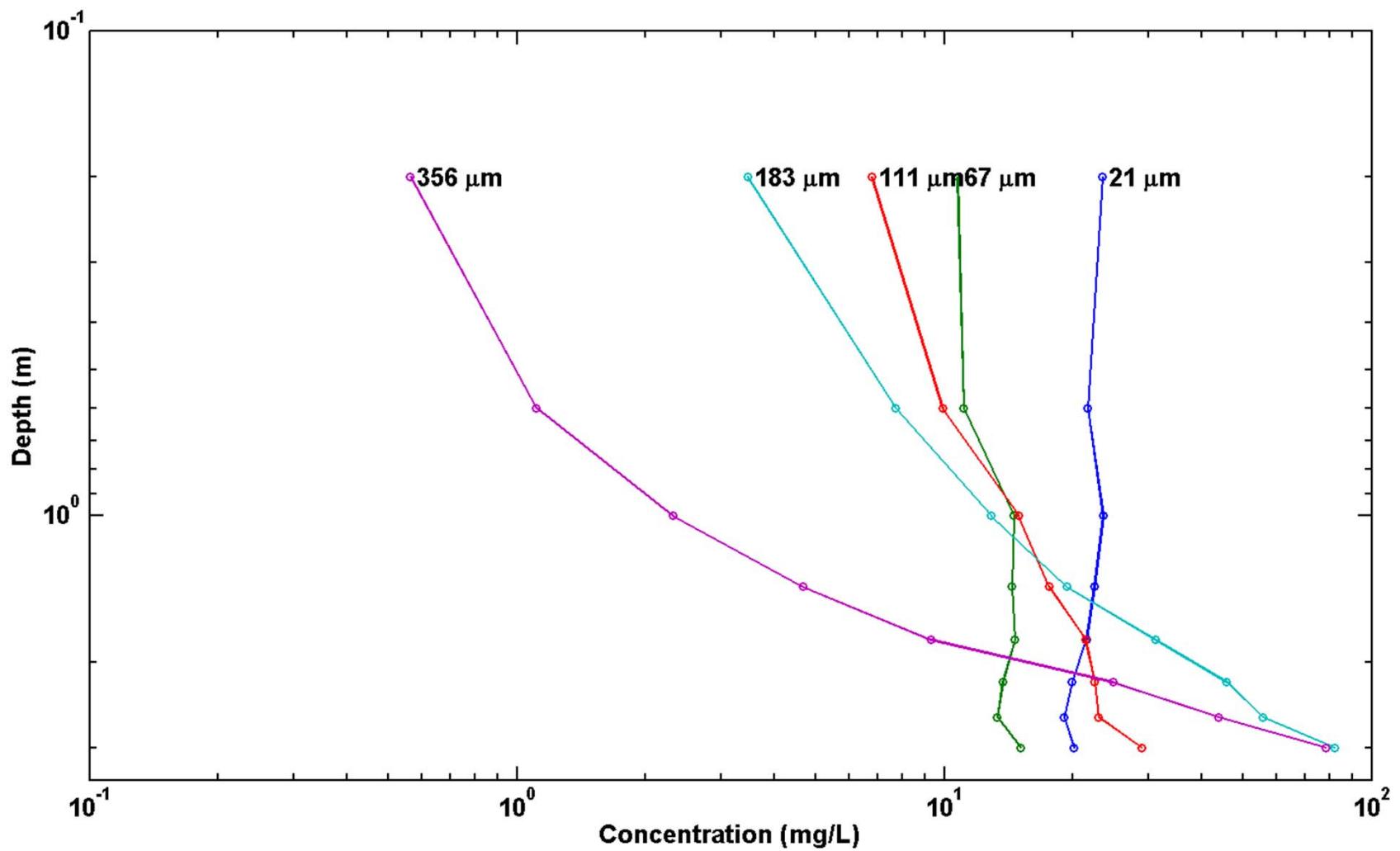
# I - Binned data and flux



# I - Sediment concentration



# I - Concentration profiles



# I - $U_*$ for individual size classes

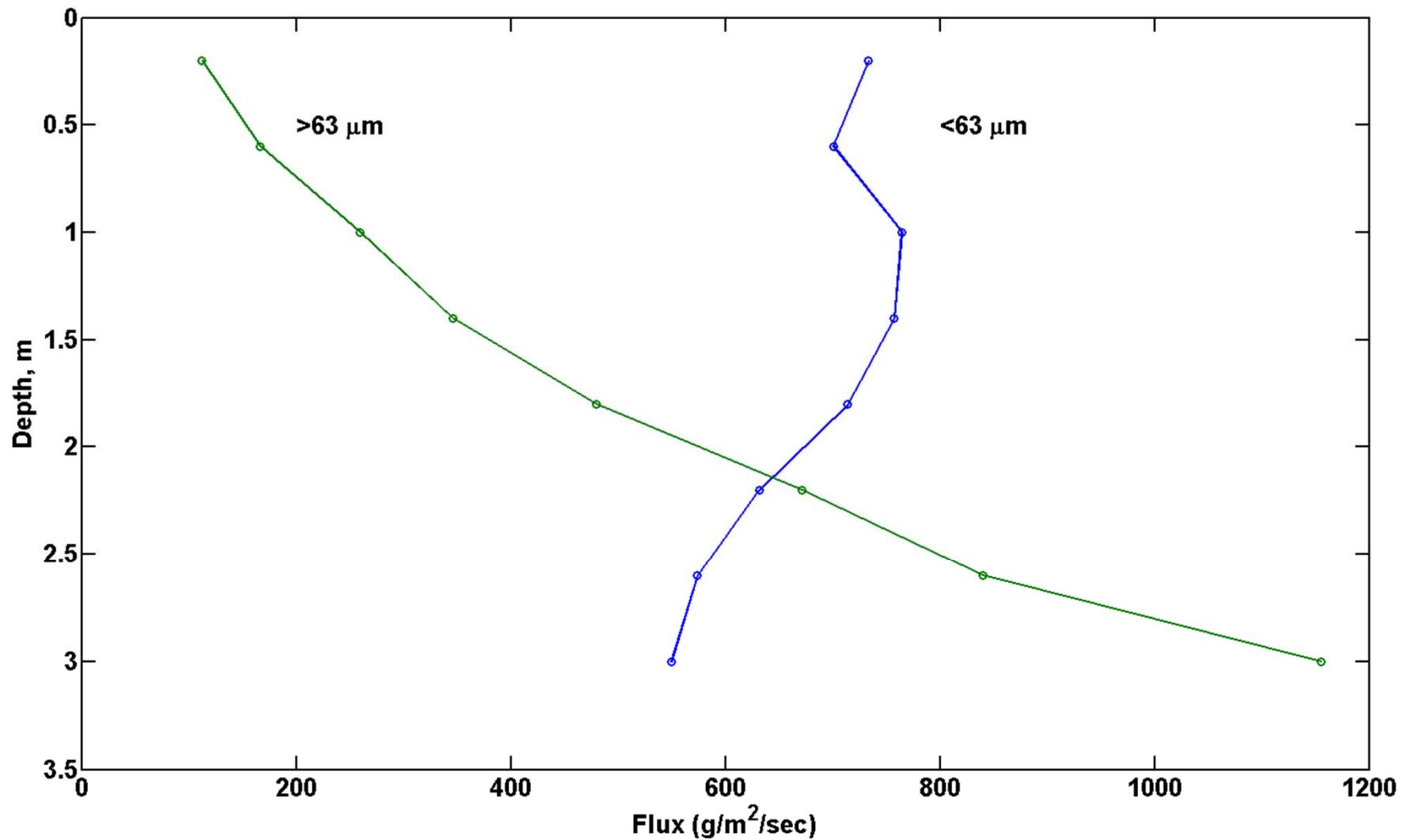
Size Class #	26	27	28	29	30	31	32
Diameter [ $\mu\text{m}$ ]	131	155	183	216	255	302	352
$U_*$ [cm/sec]	5.2	5.2	5.3	5.6	6.1	6.9	8.3

$$U_* = (D * I * g)^{1/2}; D = 4 \text{ m} \Rightarrow$$

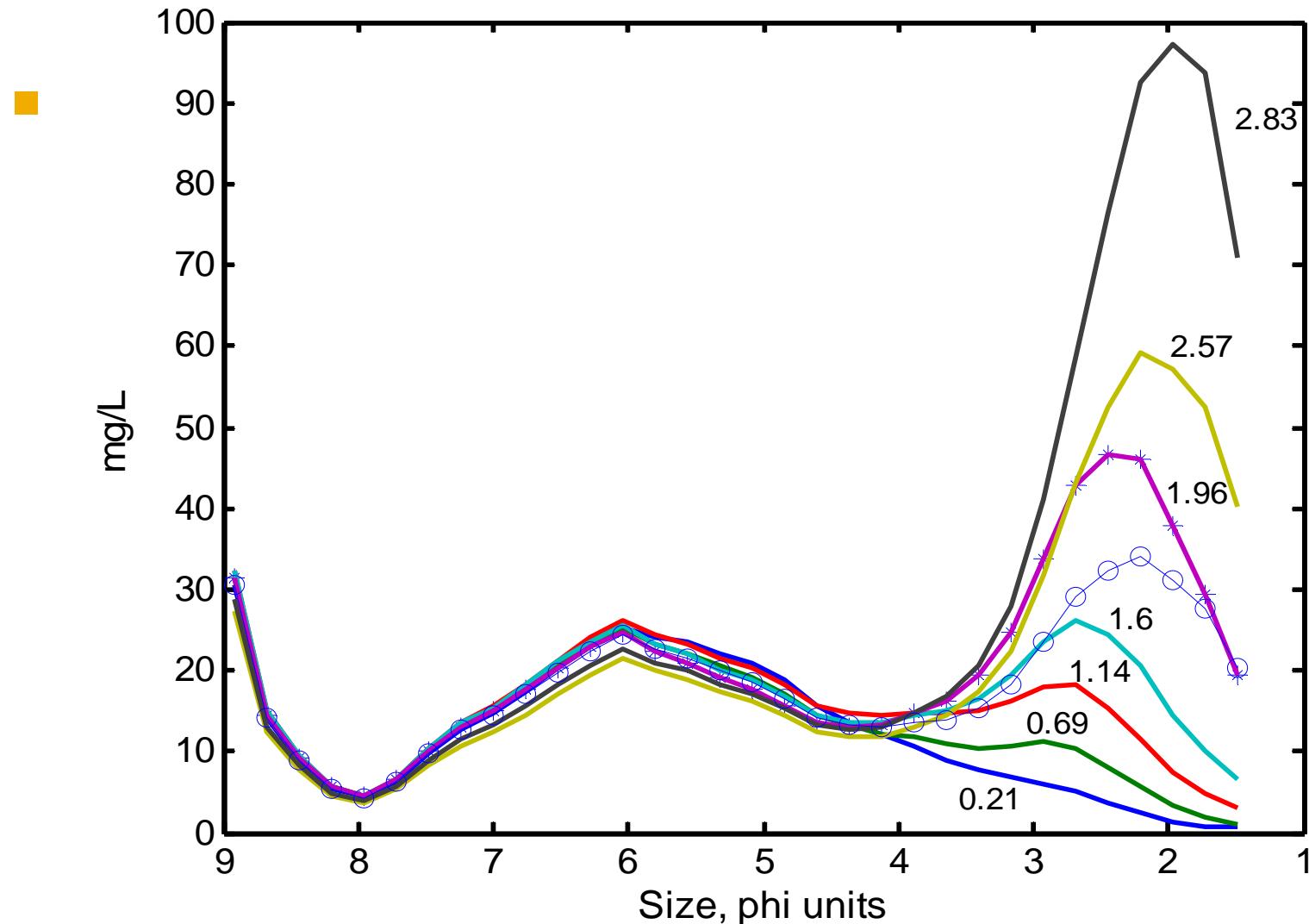
$$I = 2 \times 10^{-4}$$

(USGS reports  $3 \times 10^{-4}$  for Cowlitz River)

# Sediment flux for 2 (or more) sizes



# I - Mean PSD vs PSD at half depth



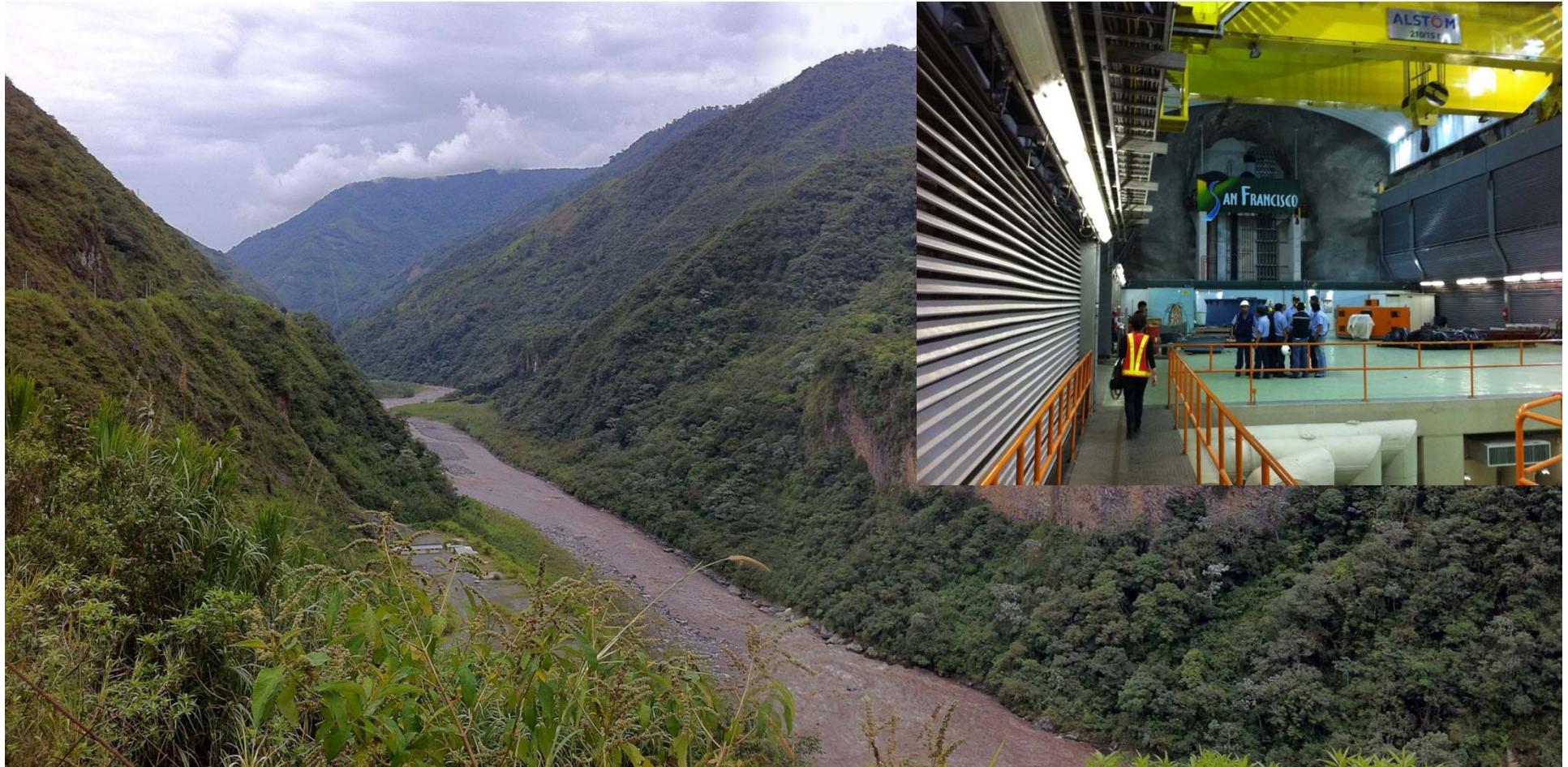
# I - Conclusions of Part-I

- SSC varies  $\times$  2-3 or more; Xmission does not
- Strong washload component  $< \sim 16 \mu\text{m}$ 
  - SMD increases  $\times 3$ ; VMD increases  $\times 5$
  - Turbidity sensors would miss SSC increase
- Vertical gradients of coarse particles yields fairly consistent  $u^*$  estimates
- Water column mean PSD  $\sim =$  PSD at half depth
  - Due to Rouse; coarse sediment concentration decays exponentially

## II – Sediment Abrasion Warnings at a Hydropower Plant, Ecuador

- **Coarse grains in high concentrations can destroy turbines by abrasion;**
- **Sequoia makes an auto-dilution Laser Diffraction system – LISST Infinite**
- **Real-time data is displayed at Control Room**
- **At hazardous conditions, warning alarms are sounded.**

# San Francisco HPP, Ecuador



# LISST-Infinite: The Turbine Sediment Monitor



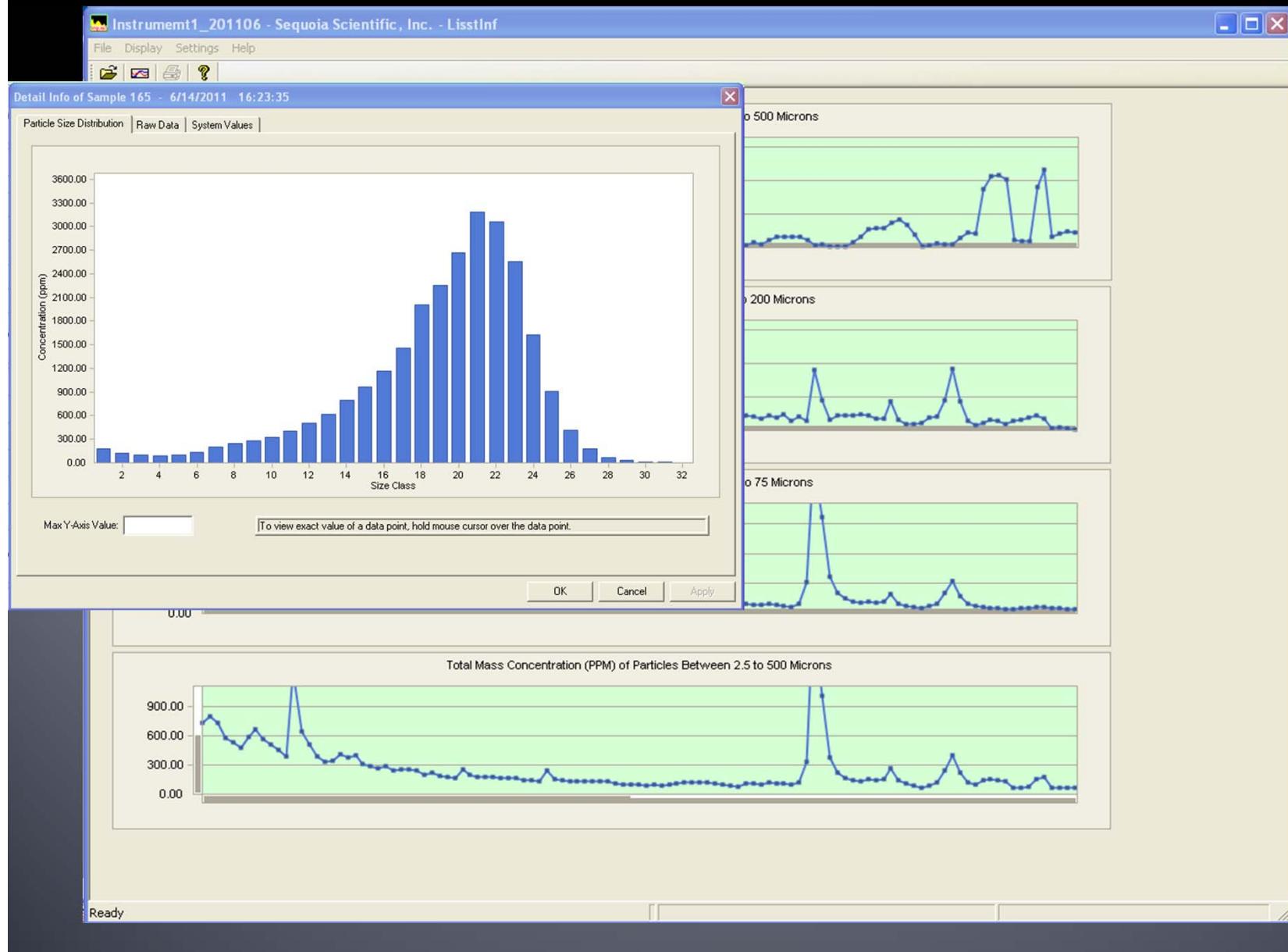
# Control Room Display



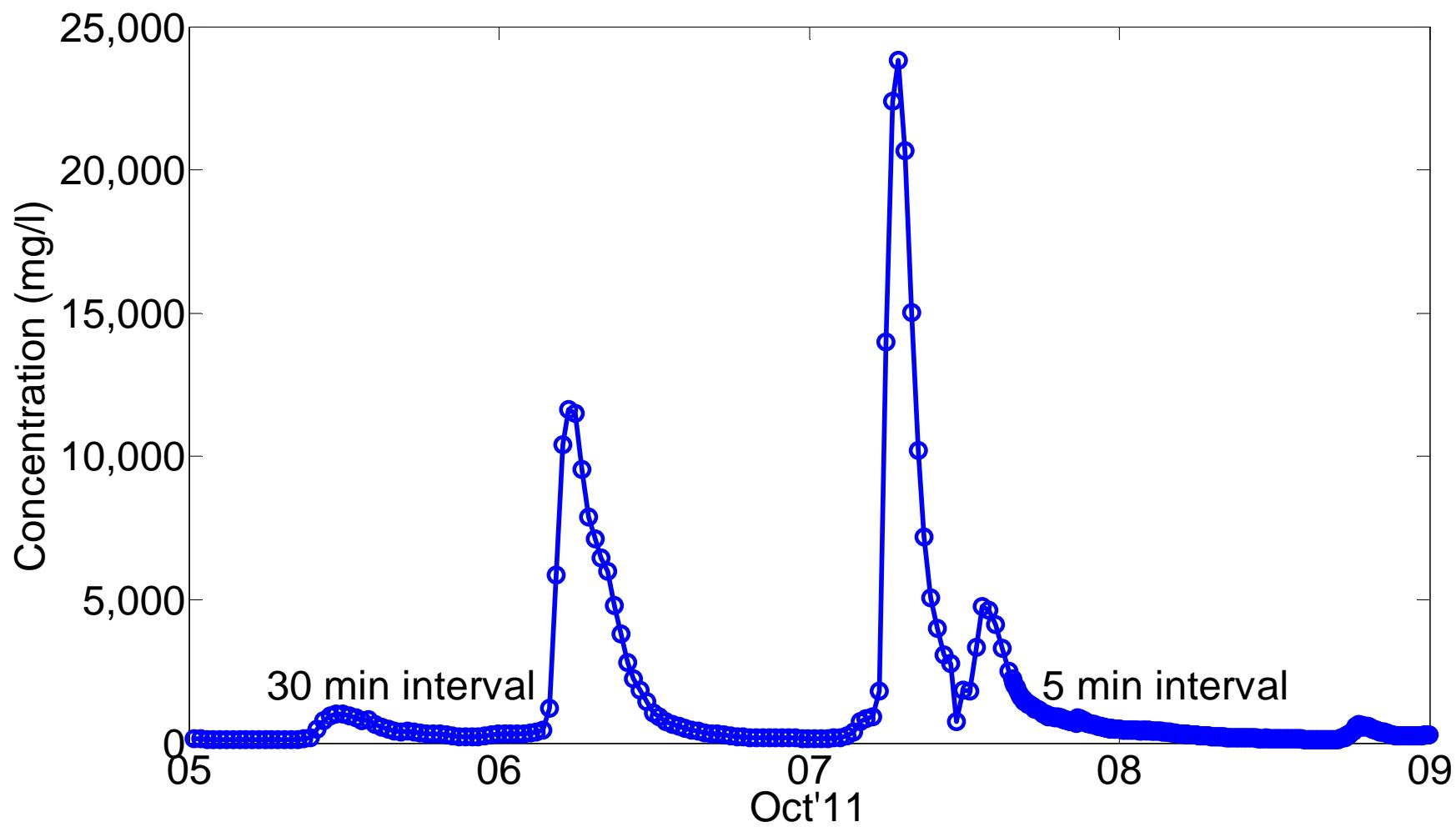
# The LISST-Infinite Alarm Feature

- Linear fit used to predict if concentration will exceed a set value – for warning
- If critical value (set by operator) is exceeded, alarm will sound
- Linear fit also predicts when water will clear

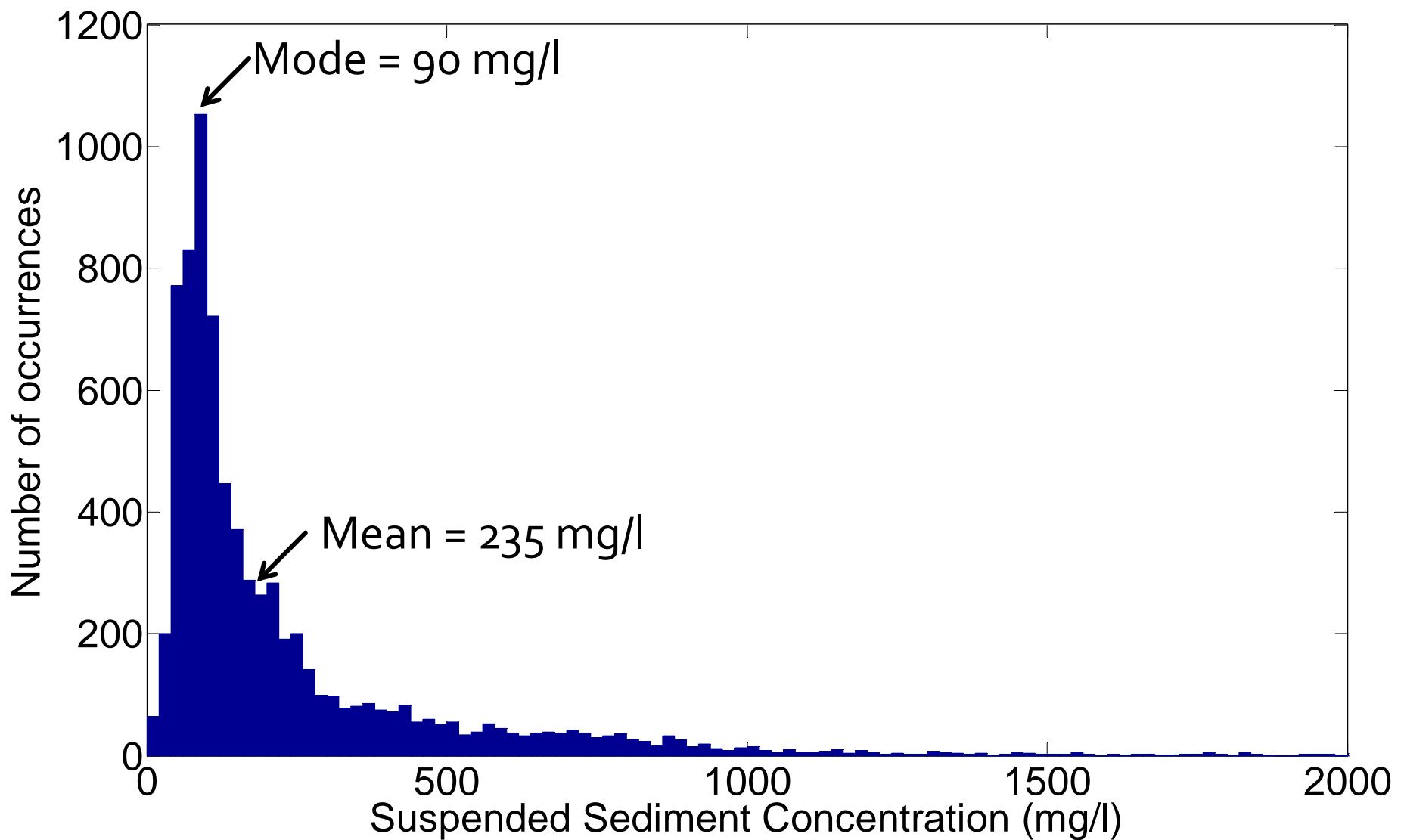
# Click to view a size distribution



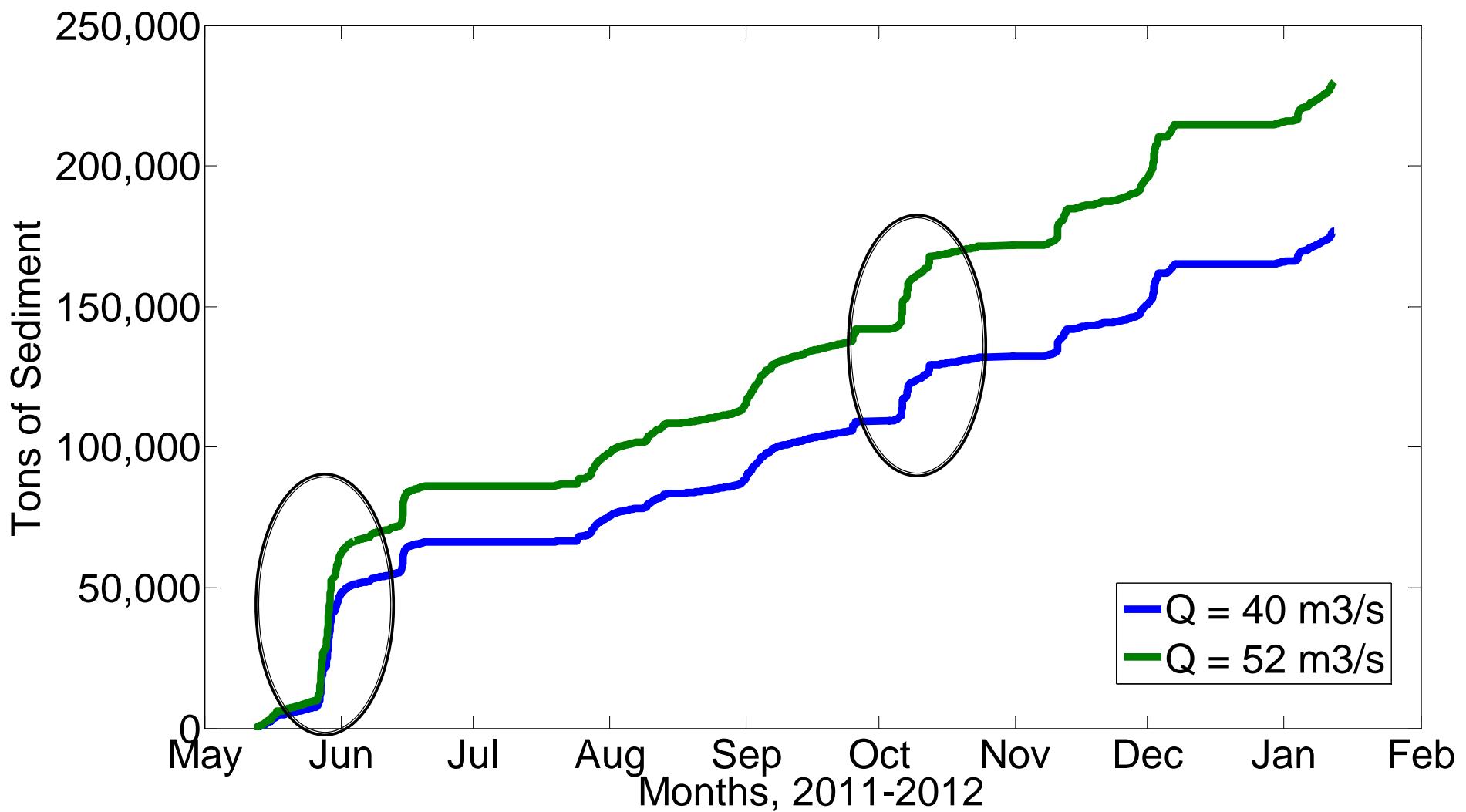
# River Sampler's Dilemma: Where to sample?



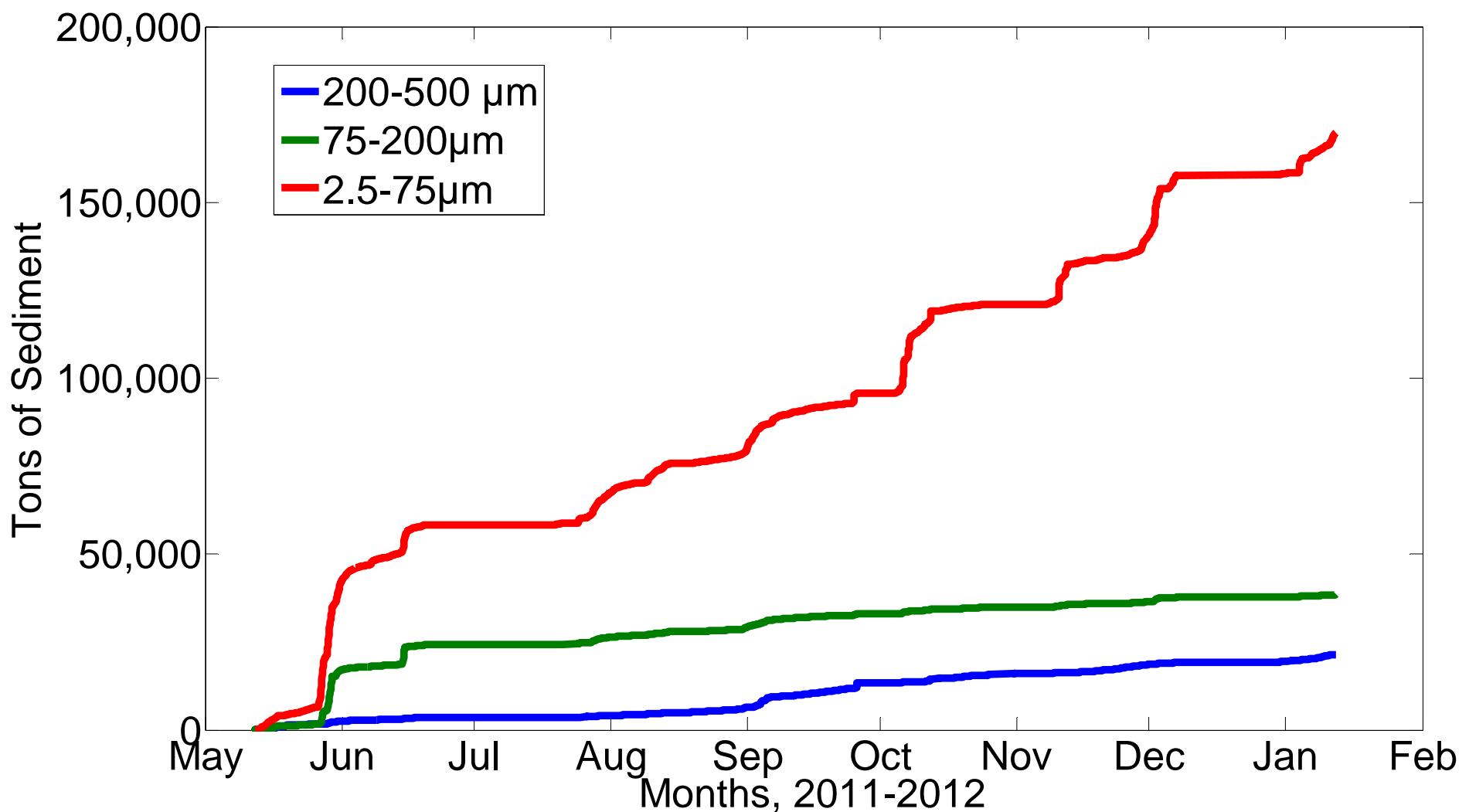
# Suspended Sediment Histogram, 7773 measurements, May'11-Jan'12



# Cumulative Sediment Load Through the Turbine, May'11-Jan'12



# Cumulative Sediment Load Through the Turbine, May'11-Jan'12



# Summary

LISST-SL and LISST-Infinite instruments



Data from a river suggest far superior method for sediment work.



Real-time data at a Hydro Power plant warns operators for turbine protection.