Operational Model for Comprehensive Inland and Coastal Monitoring

James S. Bonner, Christopher Fuller, Mohammad Islam
Clarkson University
Rivers and Estuaries Observatory Network

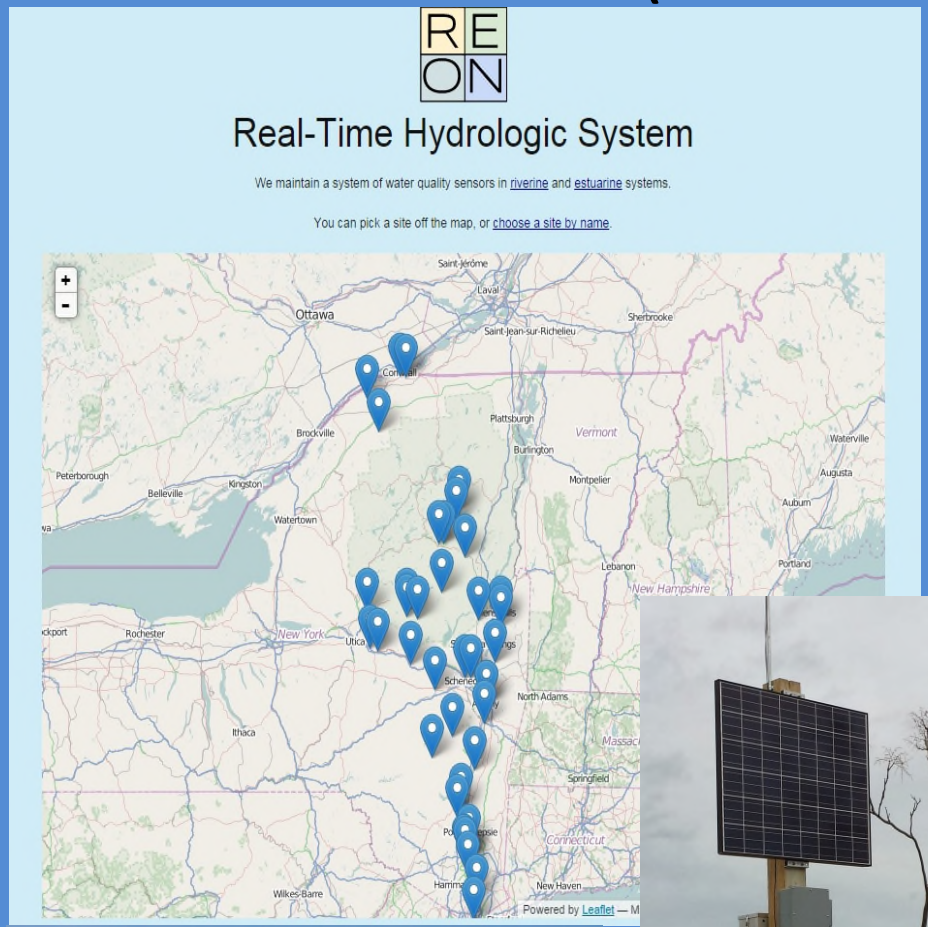
Andrew N. Ernest
University of Alabama
National Water Center

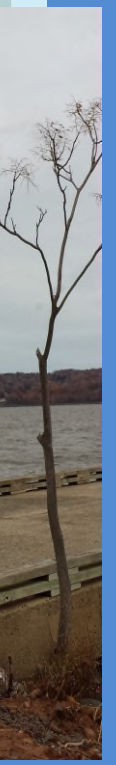
10th National Monitoring Conference
Tampa, FL, May 2-6, 2016

Beacon Institute for Rivers and Estuaries
Clarkson University

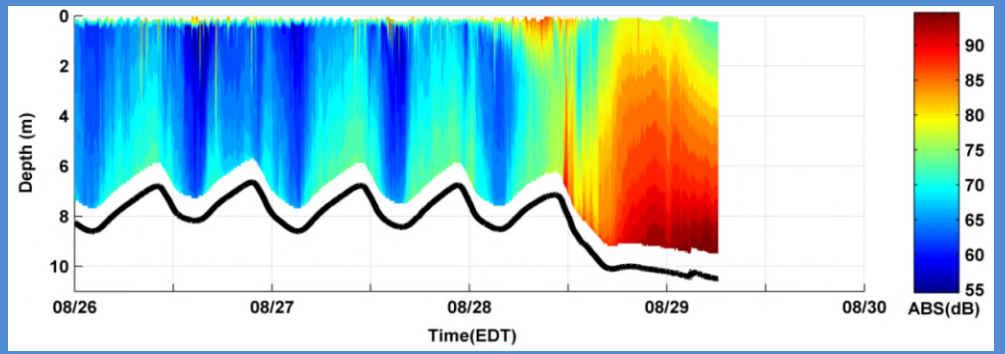
Clarkson UNIVERSITY
defy convention™

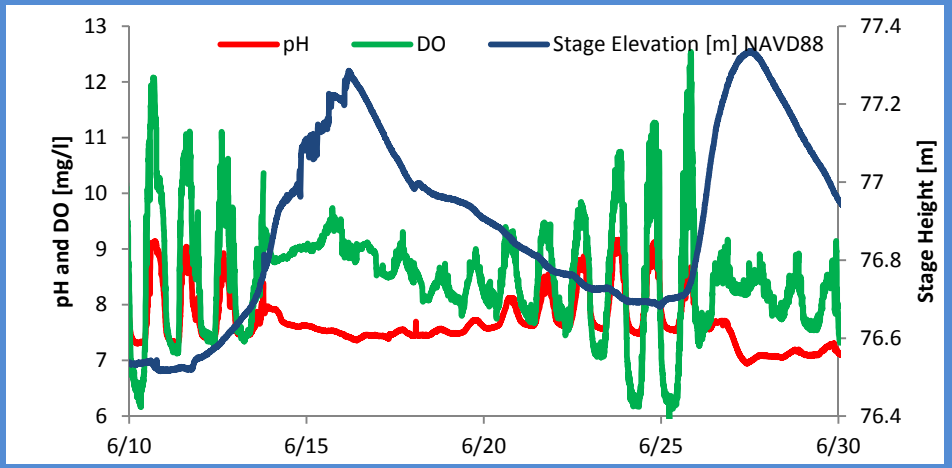
River and Estuary Observation Network (REON) (Summit to the Sea)





- Providing high resolution Spatial and Temporal data For: Environmental Decision Support , Resource Management, Enforcement/Compliance, and Environmental Science and Engineering Research Transformation
- Impact of Extreme events





EON Case Study: Sturgeon Habitat Restoration

Current threats include:

•Habitat degradation and loss from human activities (e.g., dredging, contamination, dams, water withdrawals), habitat impediments including locks and dams

Atlantic Sturgeon

•Spawn in freshwater in the spring and early summer

•Spawning occurs in moderately flowing water (46-76 cm/s) at the salt front.

•Larvae use benthic structure as refuges and Sturgeon feed there as well

•Juveniles usually reside in estuarine waters for months/years and are benthic feeders

Lake Sturgeon

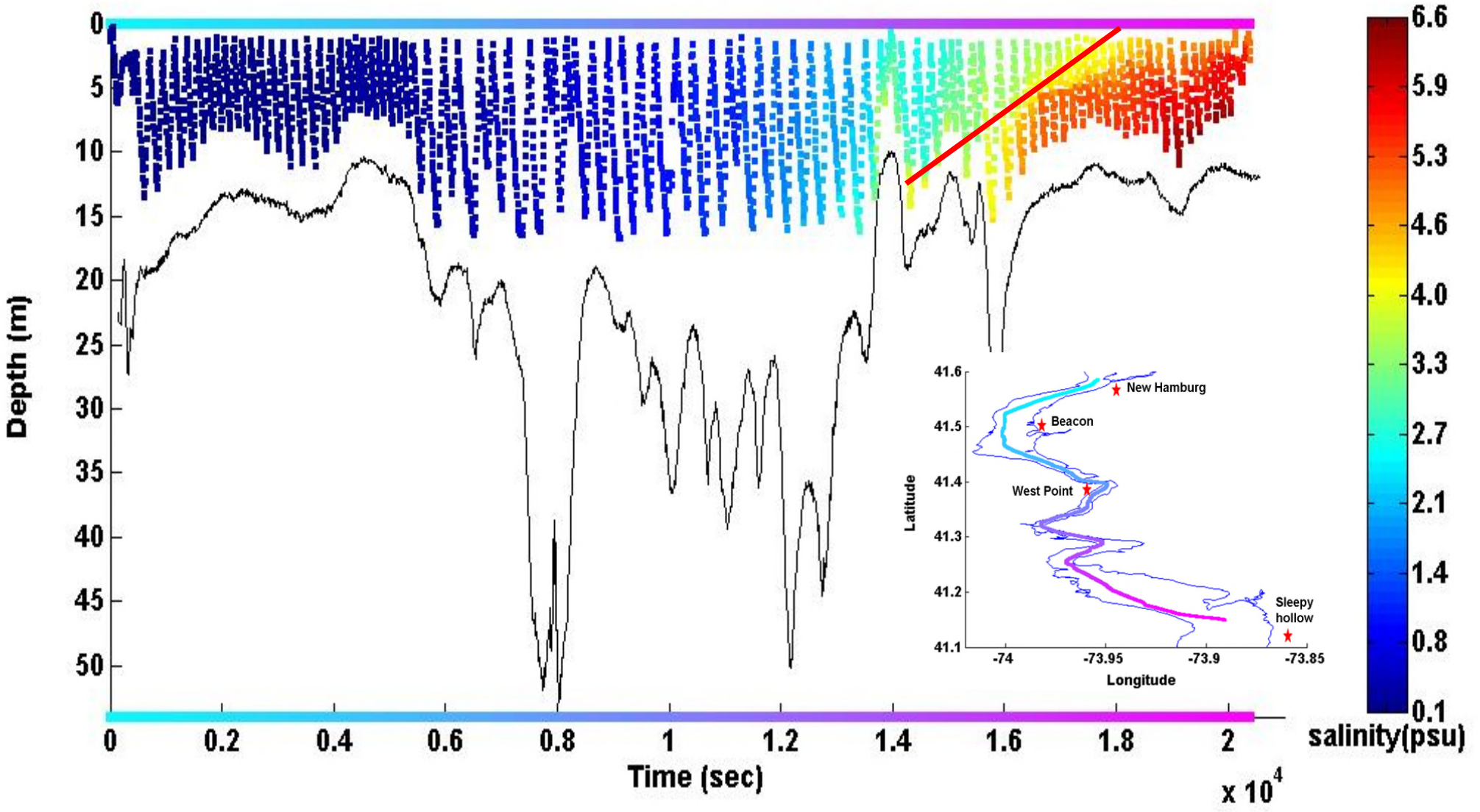
Current breaks eddies important and distance to staging areas pools are important.

Naturally variable flow regimes are critically important

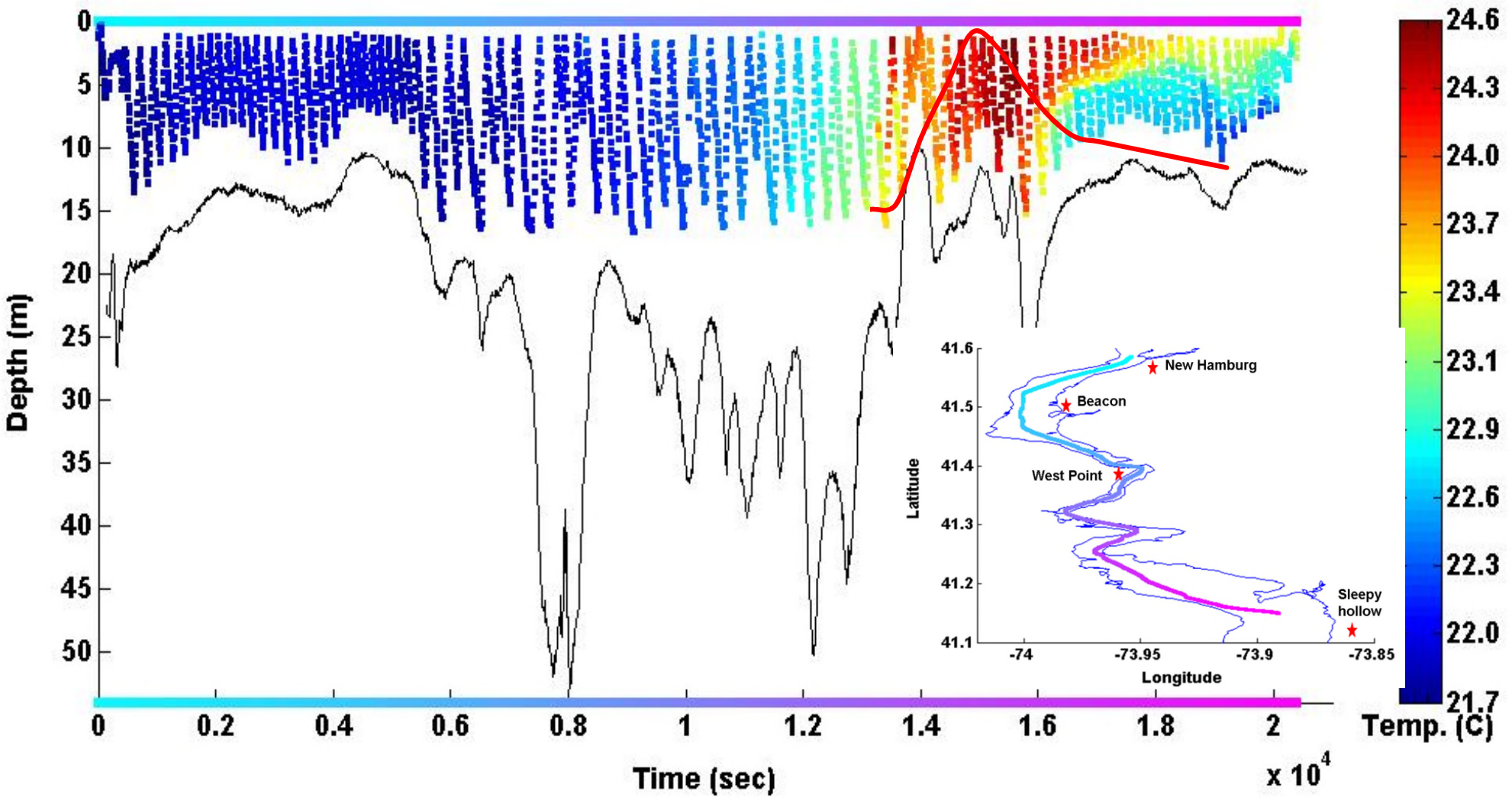
Water quality- D.O. > 7.5 mg/L

Abnormally high supersaturation can have adverse of lethal effects on embryos and larvae

High Spatial Resolution Characterization of salt wedge in Hudson River

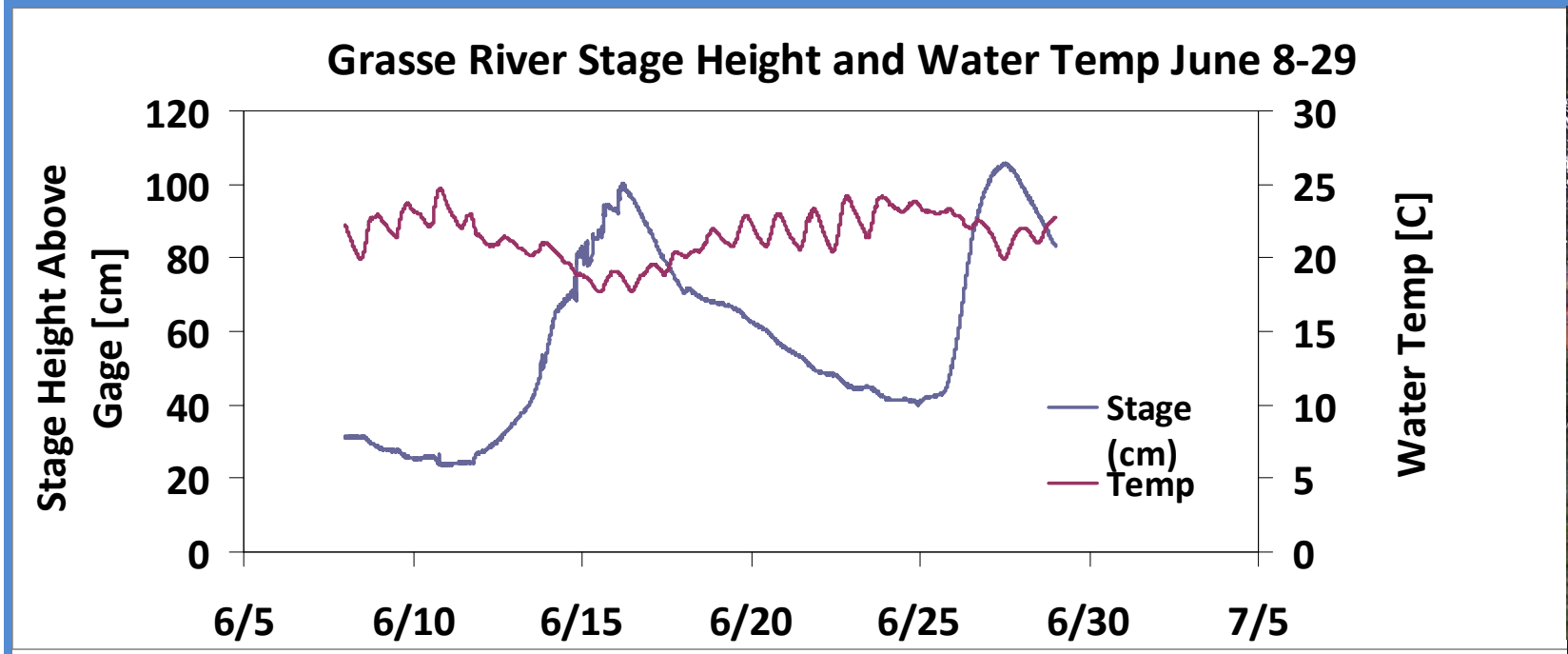


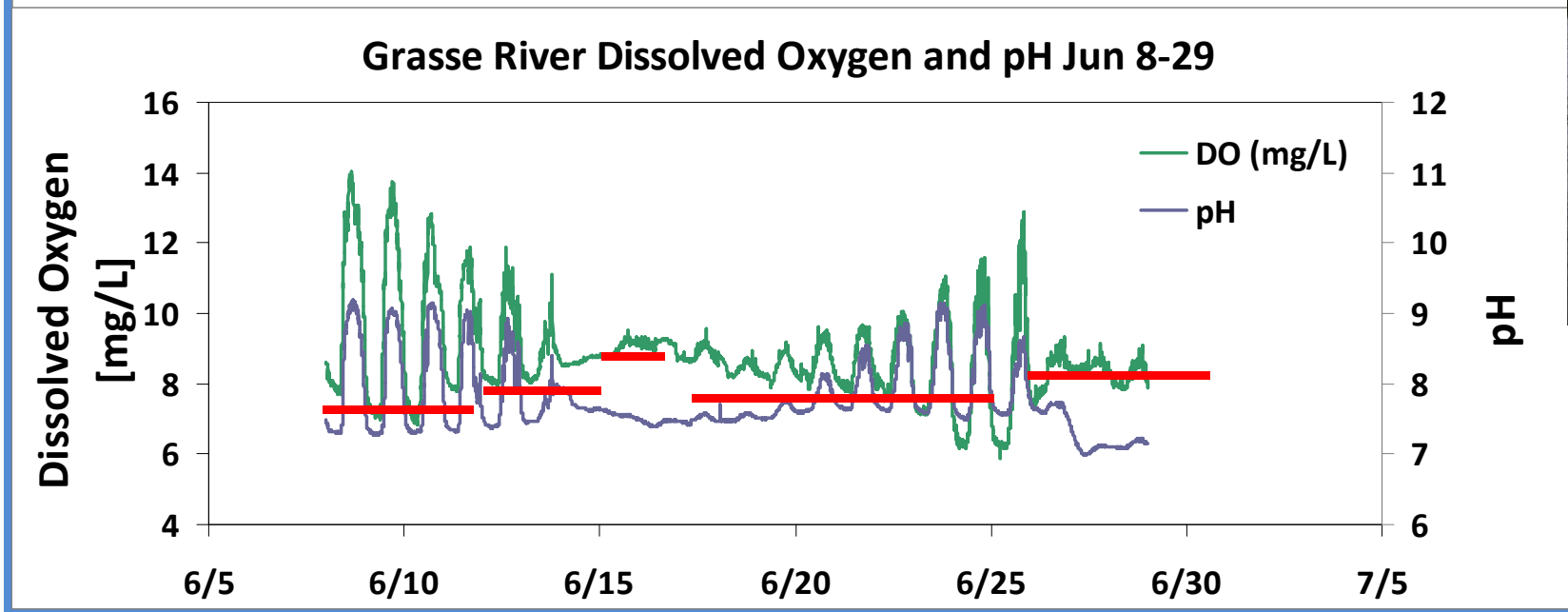
High Spatial Resolution Characterization of water temperature along the Hudson River and Estuary

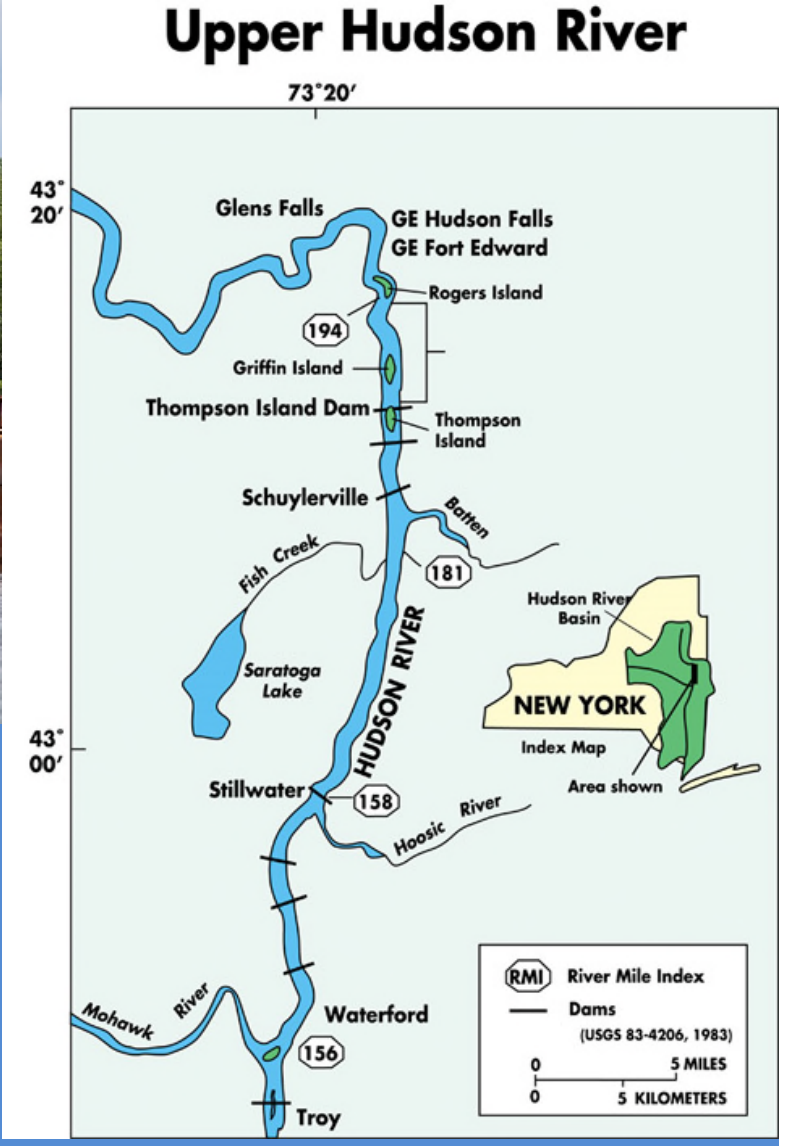


Note: Indian Point Nuclear Power Units have a cooling water discharge capacity ~2.5 billion gallons per day. Net flow of Hudson estimated as difference between Ebb and Flood flows measured at Beacon is ~50 billion gallons per day.

Temporal variation of habitat conditions at the monitoring site







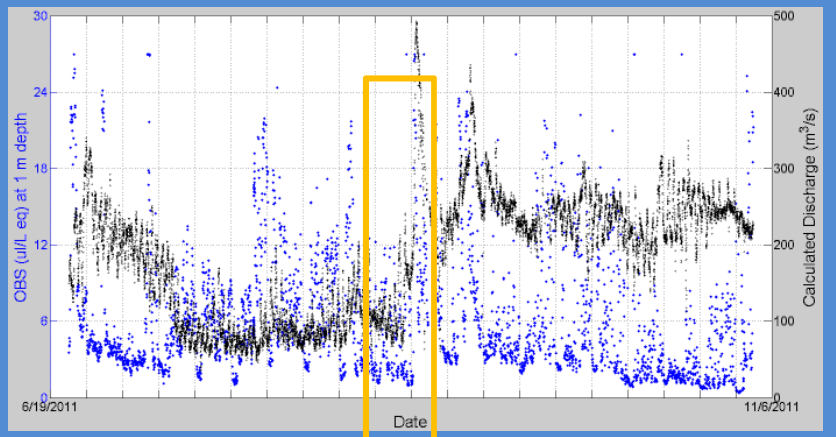
Compliance/Enforcement, Resource Management of contaminated sediments removal at the Superfund site

Targeted environmental dredging of PCB-contaminated sediment from a 40-mile section of the Upper Hudson River.

•Dredging was chosen as preferred remedy to address PCBs in river bottom sediments in Upper Hudson River: Goals of the Remedy (ROD; EPA 2002) :Reduce PCB concentrations in fish, river water, bottom sediment and to minimize the long-term downstream transport of PCBs in the river /estuary.

Impacts of dredging activities on PCB level in the water column

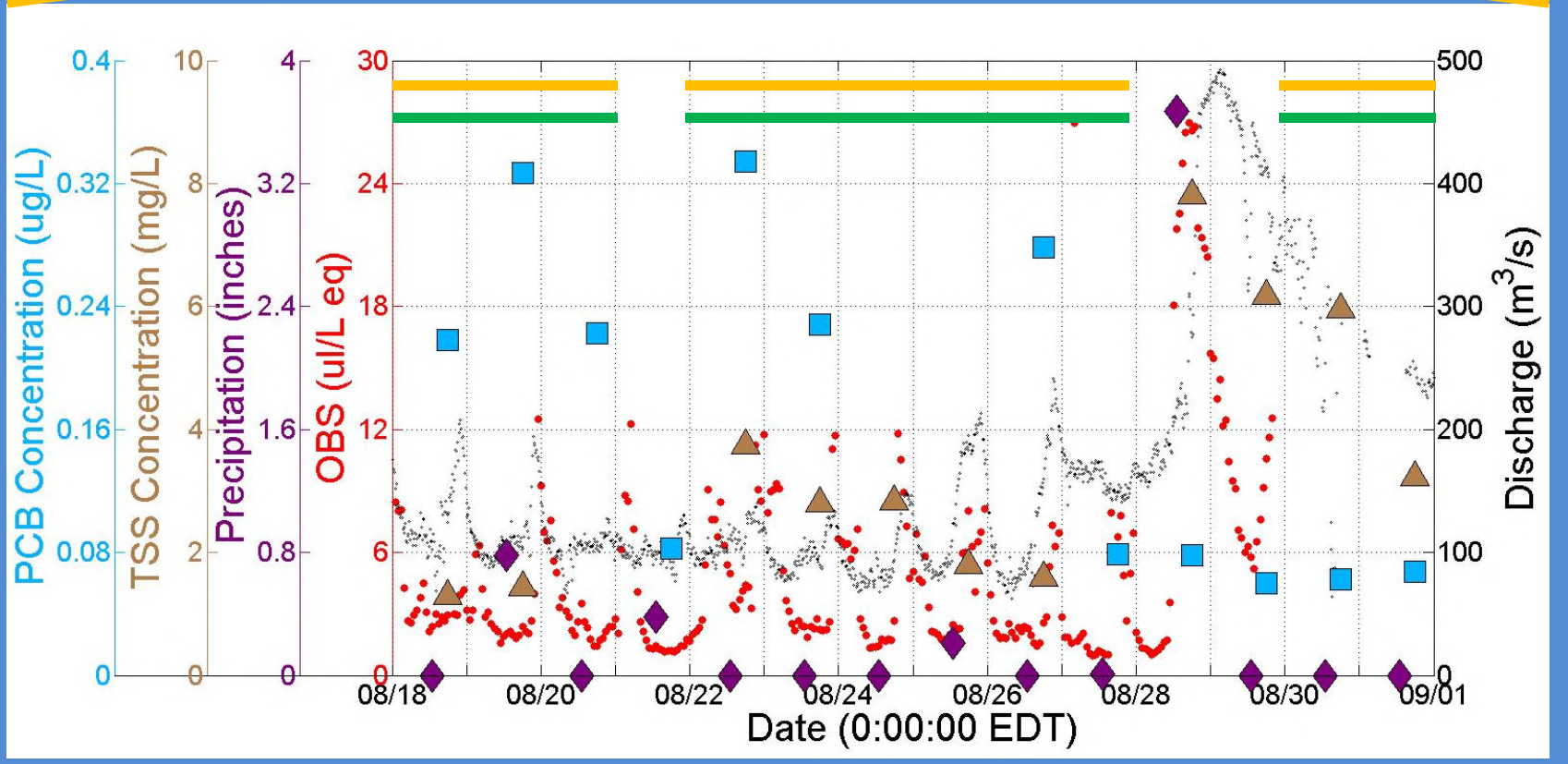
- Daily Rainfall (Glens Falls Airport)
- Daily TSS Conc. (Courtesy GE)
- Daily PCB Conc. (Courtesy GE)



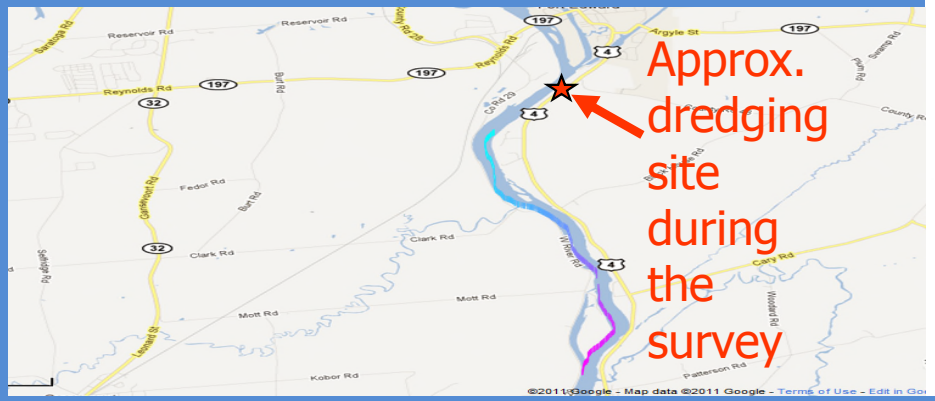
BACKFILLING

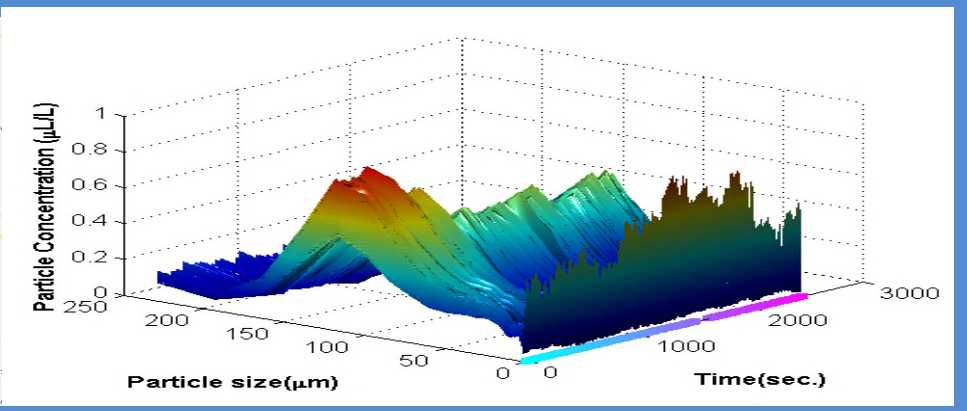
DREDGING

6/19/2011 — 11/6/2011

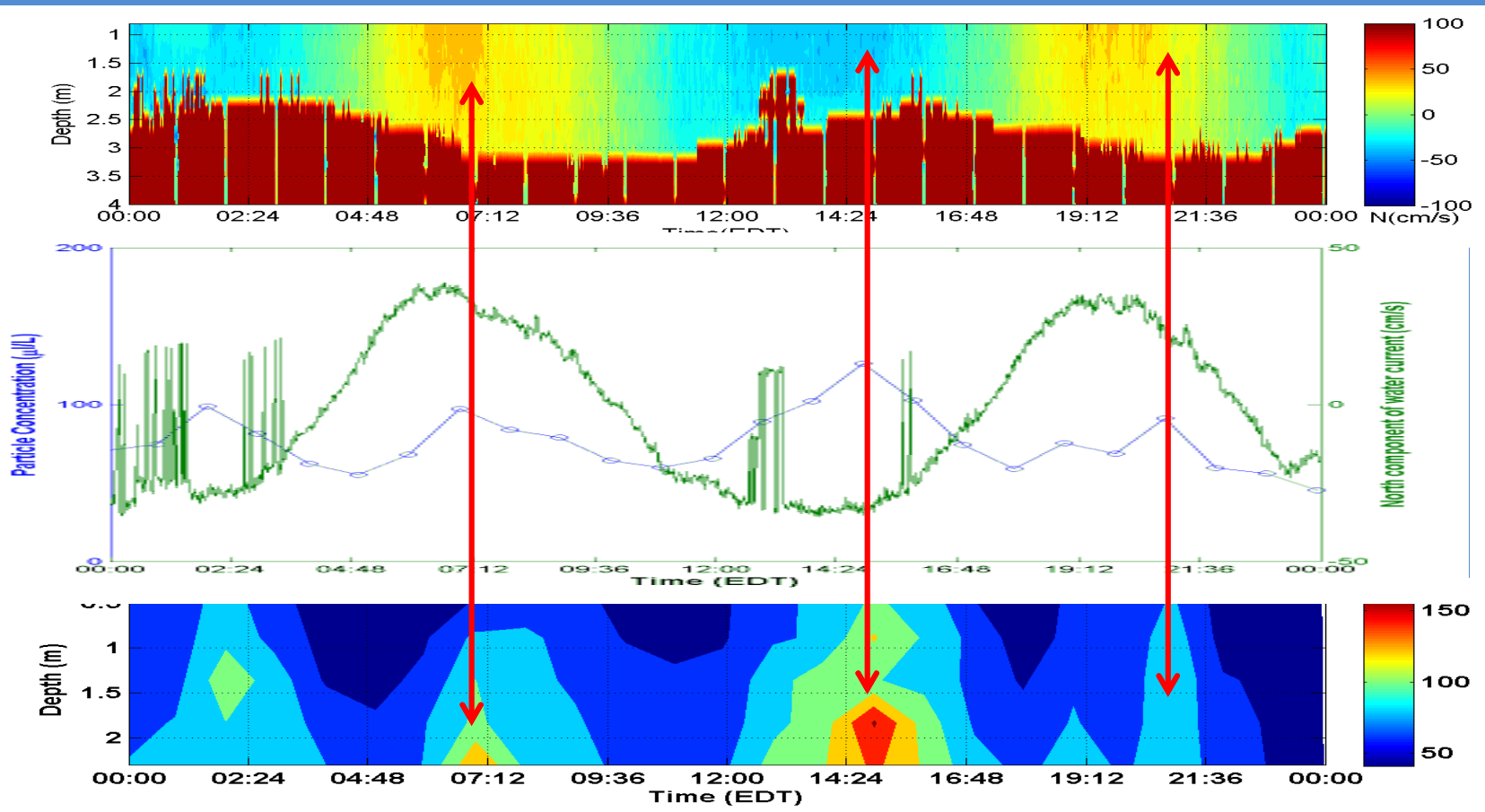


Mobile platform survey upper Hudson data





Robotic platform survey Lower Hudson data

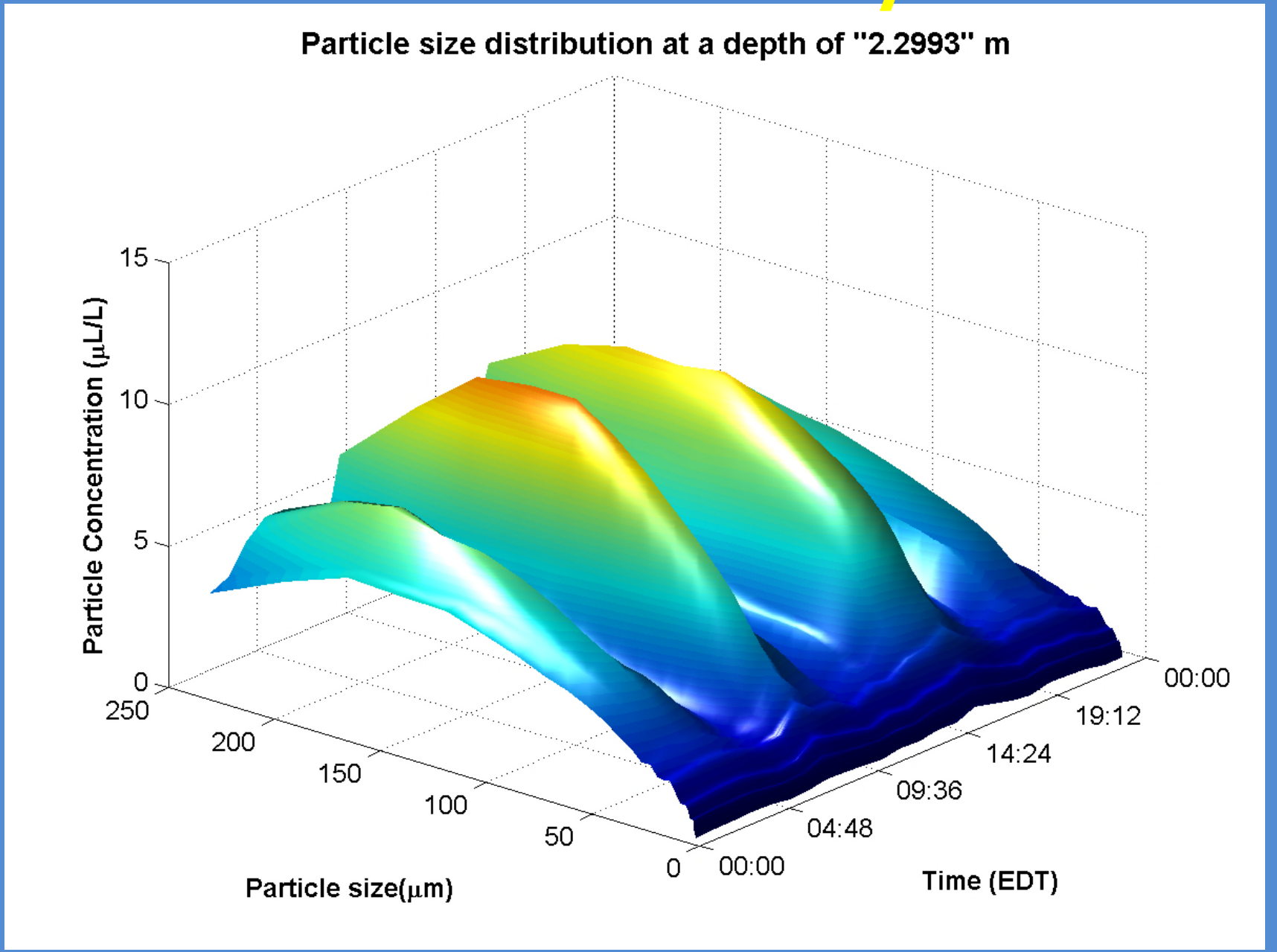


Velocity

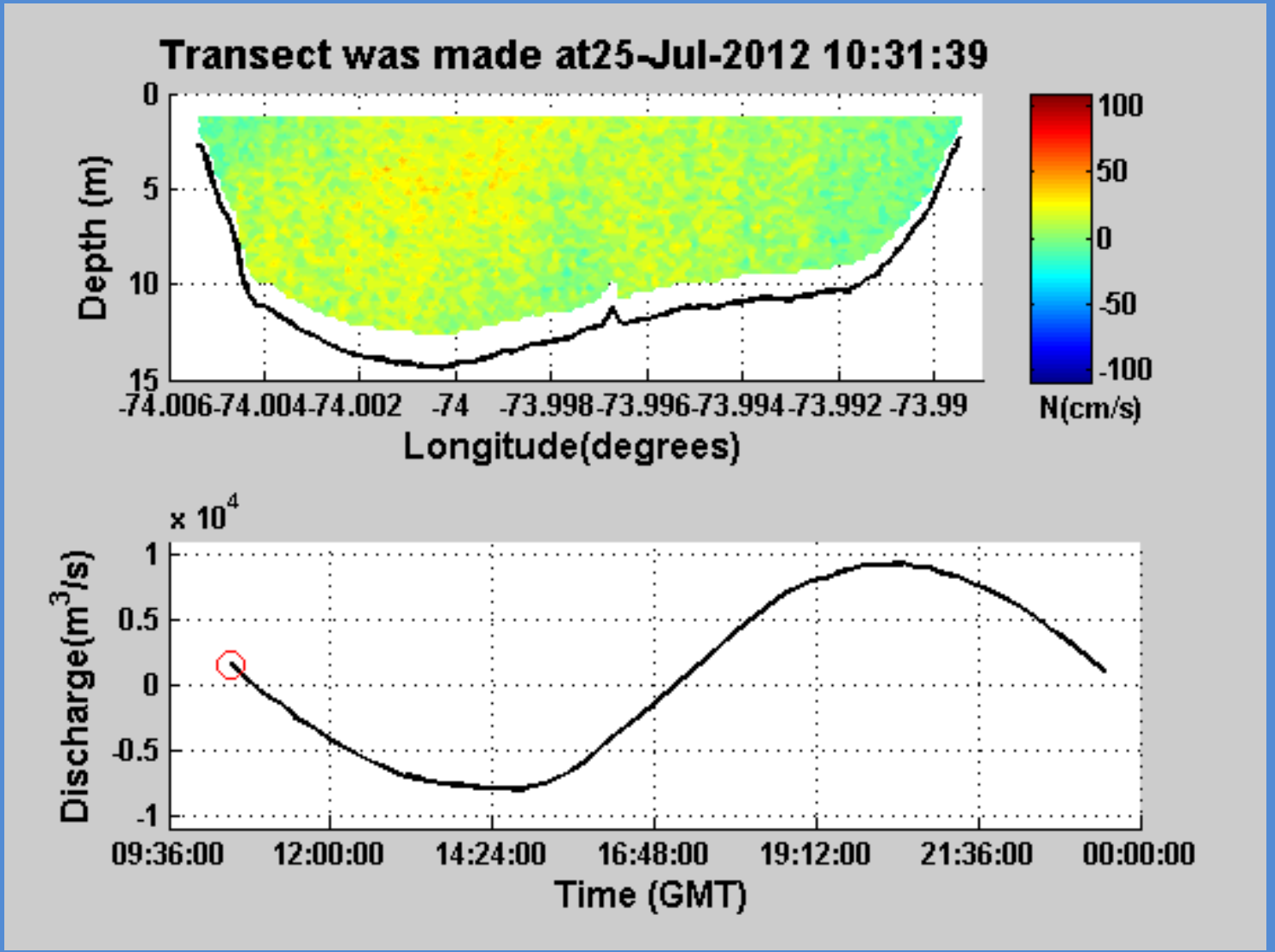
Velocity & Particles

Particles

Robotic Samper Characterization Variation of Particle Distribution Over Tidal Cycle



Micro Hydrodynamics over a tidal cycle

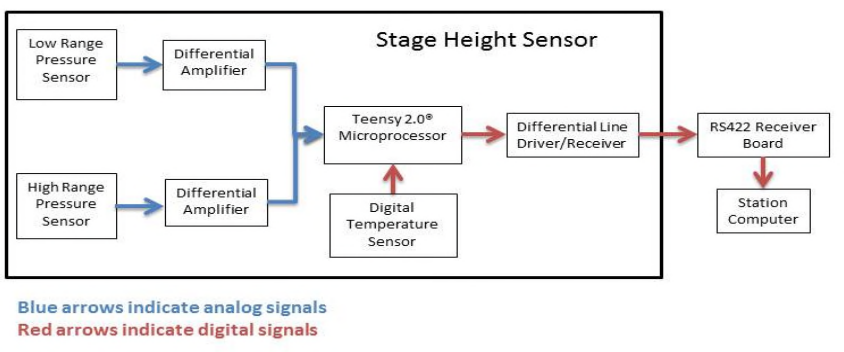


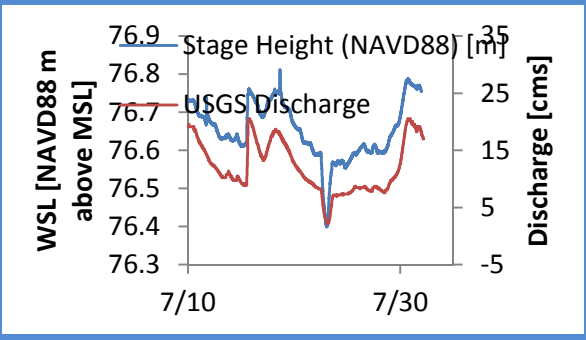
REON Operation Model Objectives

- Establish, maintain, and operate a comprehensive watershed monitoring network.
- Requires establishment of sustainable operational model.
  - Reduce capital cost
  - Reduce unit data costs
  - Minimize operational cost
  - Minimize capital depreciation
  - Maximize services provided by observatory network

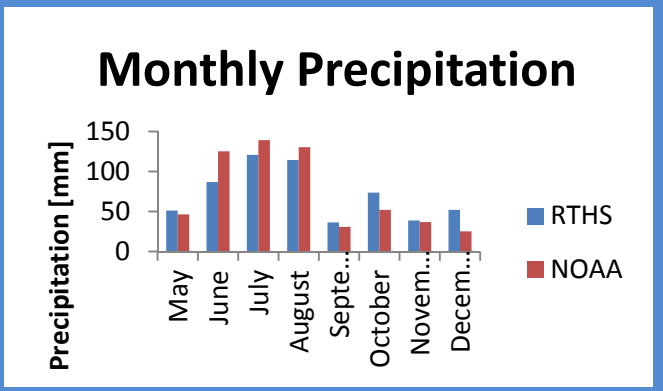
Reduce Capital Cost

- Sensor technology.
  - Enabling technology borne through low-cost microprocessors (Teensy)
  - Incorporated into sensor designs.
    - Stage height
    - Precipitation
    - Water quality
    - Integrated network
  - Standardized/modular design
  - Integrated systems





Developed water quality sonde can be built for approximately $2,000. Comparable commercially available sonde ~$20-25K with sufficient performance to characterize parameter variability and range.



Reduce Unit Data Costs

- Application of surrogate measurements

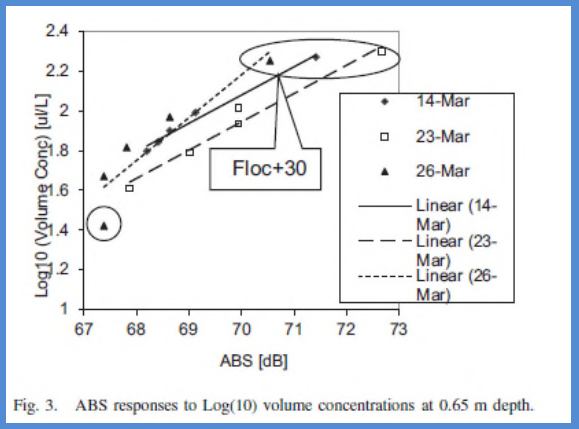
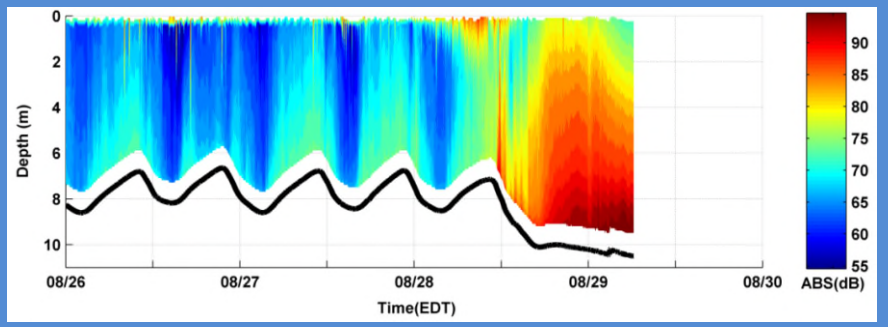
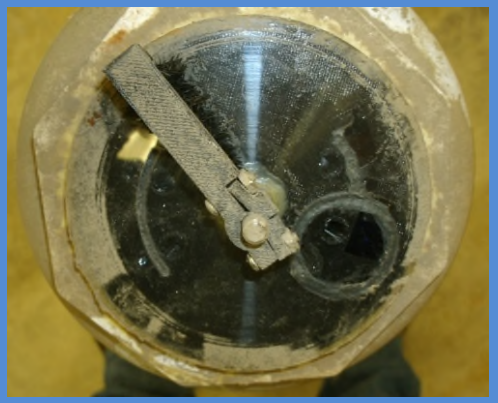
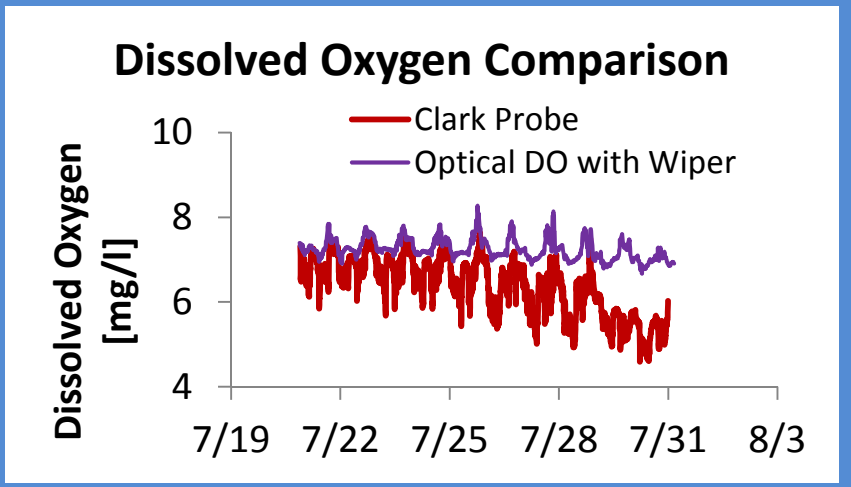


Fig. 3. ABS responses to Log(10) volume concentrations at 0.65 m depth.



- Minimize service requirements through maximizing service intervals.

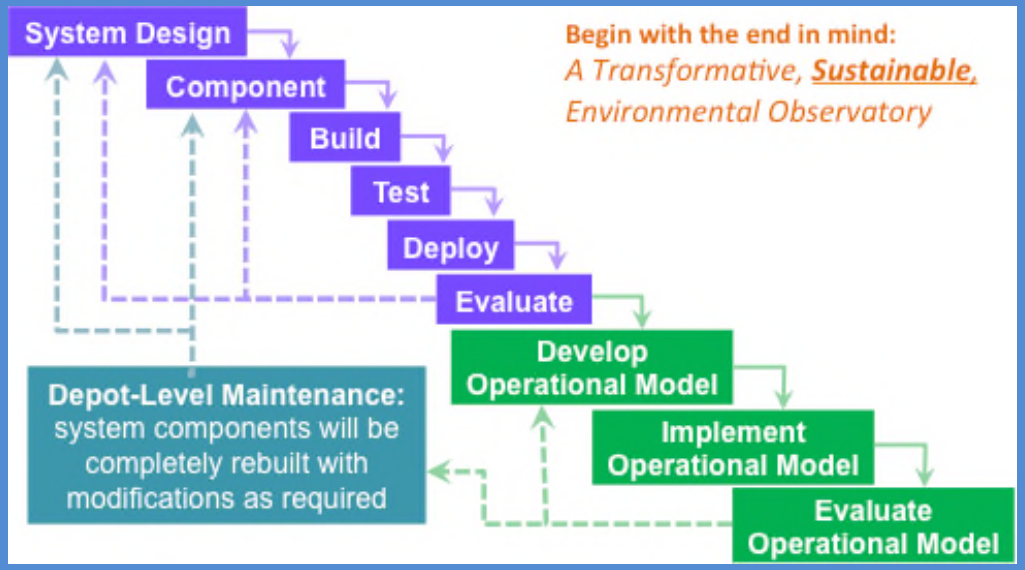




- Maximize parameter counts of developed sensors and sensor nodes (pH, DO, salinity, turbidity, chlorophyll, CDOM, atmospheric conditions, water level, water temp, etc.)

Comprehensive Iterative Adaptive (CIA) Development Process

- Cyclical process



- Strengths and weakness identified in evaluation step define design criteria that are then incorporated into system/component designs.
- Allows observatory evolution resulting from advances in technology and changes in parameters of interest.
- Prevents perfection from being the enemy of good
  - There is never a perfect system. Always room for improvement.

Depot Level Maintenance

- CIA development processes linked to Depot Level Maintenance where:
  - Field service is limited to lower-level maintenance activities (e.g. precipitation gauge services, sonde exchanges, SD card replacement)
  - More advanced services are conducted at Depot
    - Performed at intervals less than normal duty cycle of equipment where components are replaced prior to expected failure .
    - Services Include
      - Instrument calibrations
      - Refurbishment and repairs
      - Component and operating systems upgrades.
  - System component upgrades borne through CIA process are continuously incorporated into REON at a rate defined service interval.
- Benefits
  - Continuous upgrades implemented at frequency defined by duty cycle.
  - Minimizes personnel requirements (e.g. man hours and technical level) for routine services
  - Maximizes network capital cost through continuous replacement of obsolete technology with the seamless integration of the most advanced of system/component.

Design for Manufacture, Assembly, and Operations

- Depot Level Maintenance is integrated with manufacturing process.
  - maintenance is performed on the manufacturing assembly line
  - Component performance evaluated against factory specification
    - Components failing specification are replaced
  - Final is a completely refurbished system
    - systems have modular designs to streamline manufacture and refurbishing

Conclusions

- High frequency spatial and temporal monitoring is critical to characterize dynamic changes in hydrodynamics, micro-hydrodynamics, water column water quality, and benthic habitat conditions.
- Real time observatories are valuable entities supporting resource management and research objectives.
- Costs (capital and operating) continue to threaten EONs.
- REON has demonstrated the ability to lower EON costs through application of enabling technology in a comprehensive and end-to-end observatory design.
- CIA process has been developed inside a Depot Level Maintenance program to ensure EON sustainability.