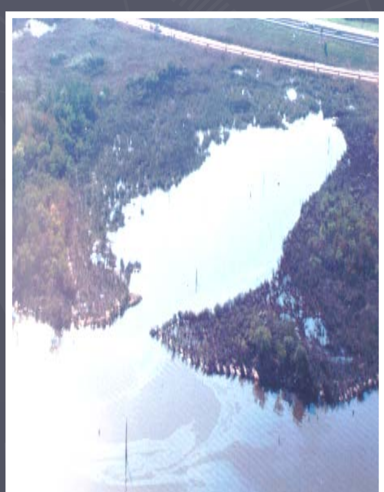
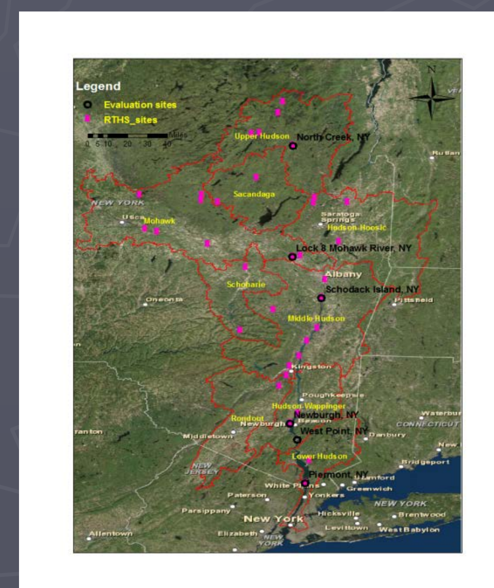
REON: River and Estuary Observation Network

40+ years of Evolution Implementing New Enabling Technology

1974 1994 1997 2002 2007 2009 2015

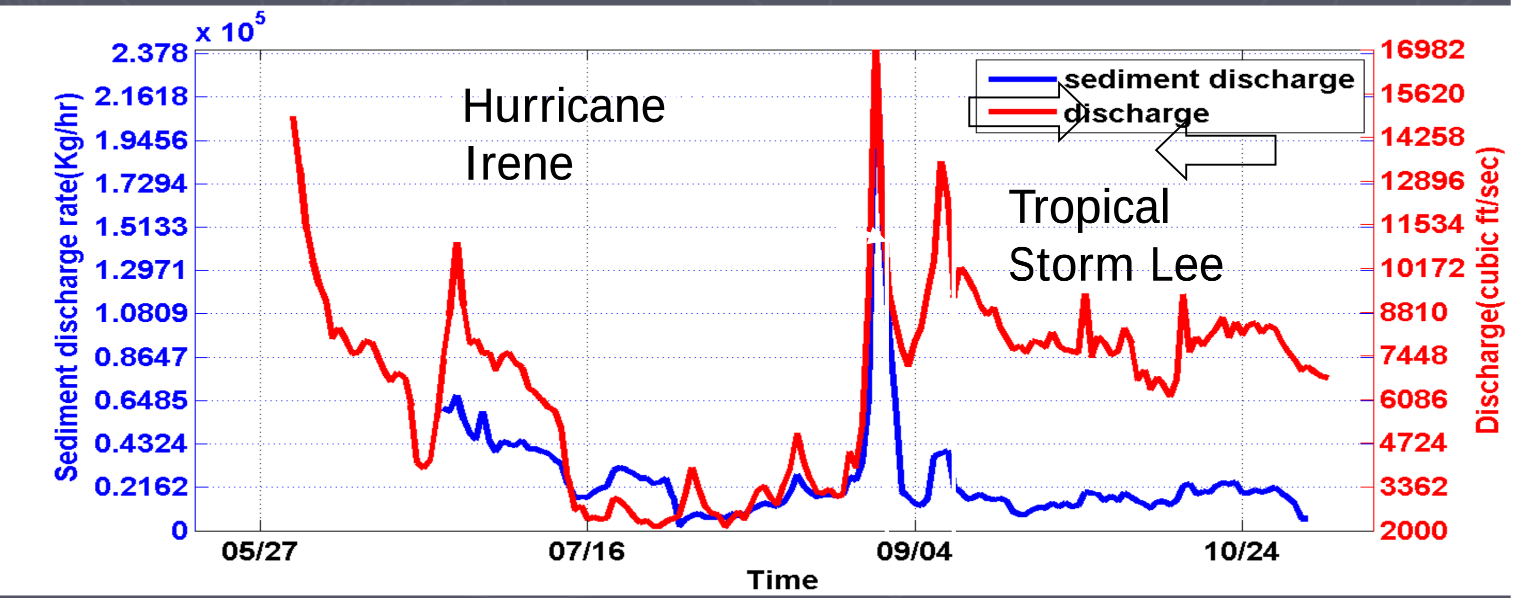




Environmental Monitoring Paradigm Shift

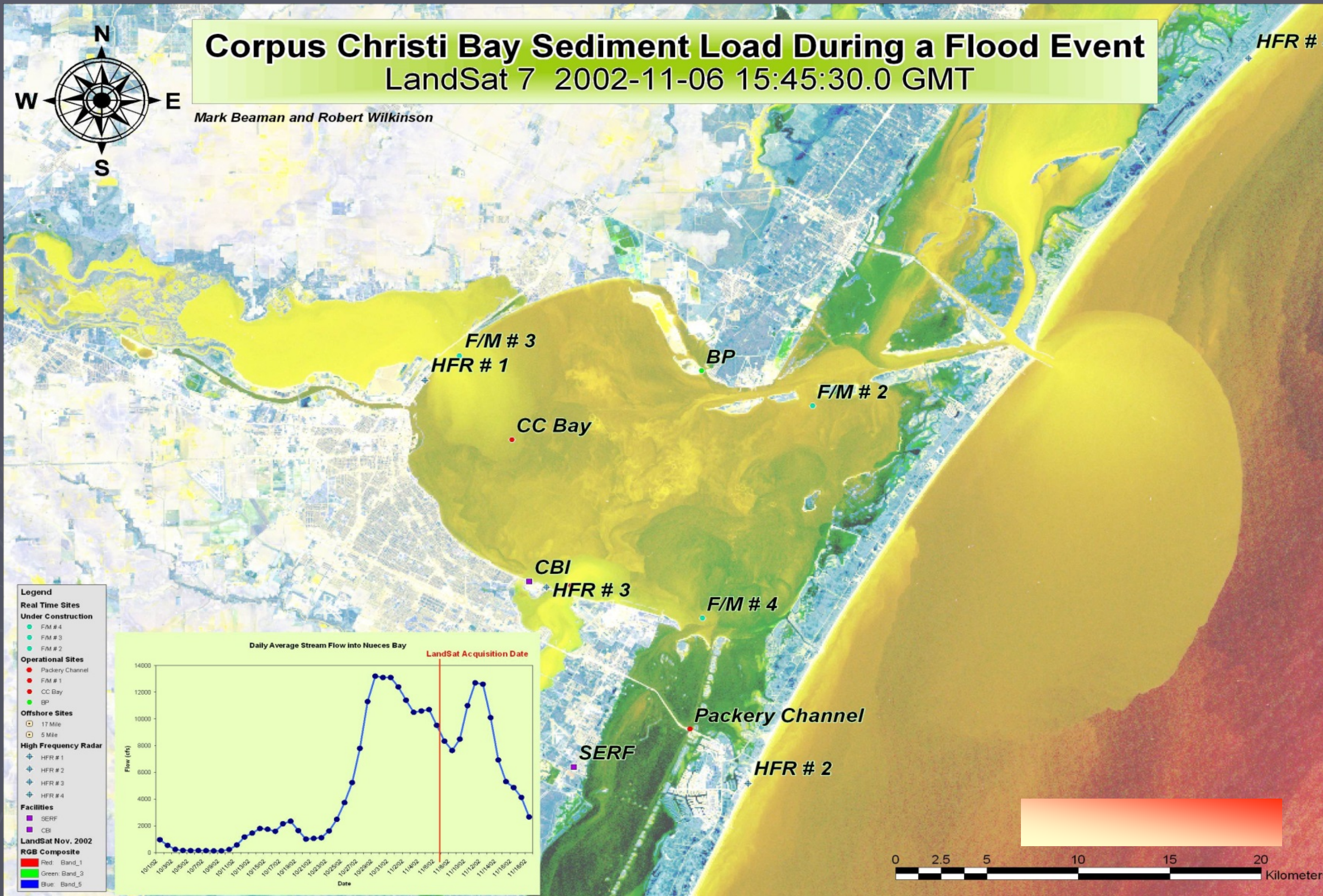
(99% change 1% time – sample at inherent frequency)

- Environmental change occurs as a series of episodic events
  - Requires continuous long term monitoring at high temporal and spatial resolutions that will transform Environmental Science and Engineering
    - Characterization of frequency, intensity & duration of event
    - Identification of long term change, in situ mechanistic studies
    - Other benefits include: predictive modeling, spills, emergency response, compliance and regulatory.

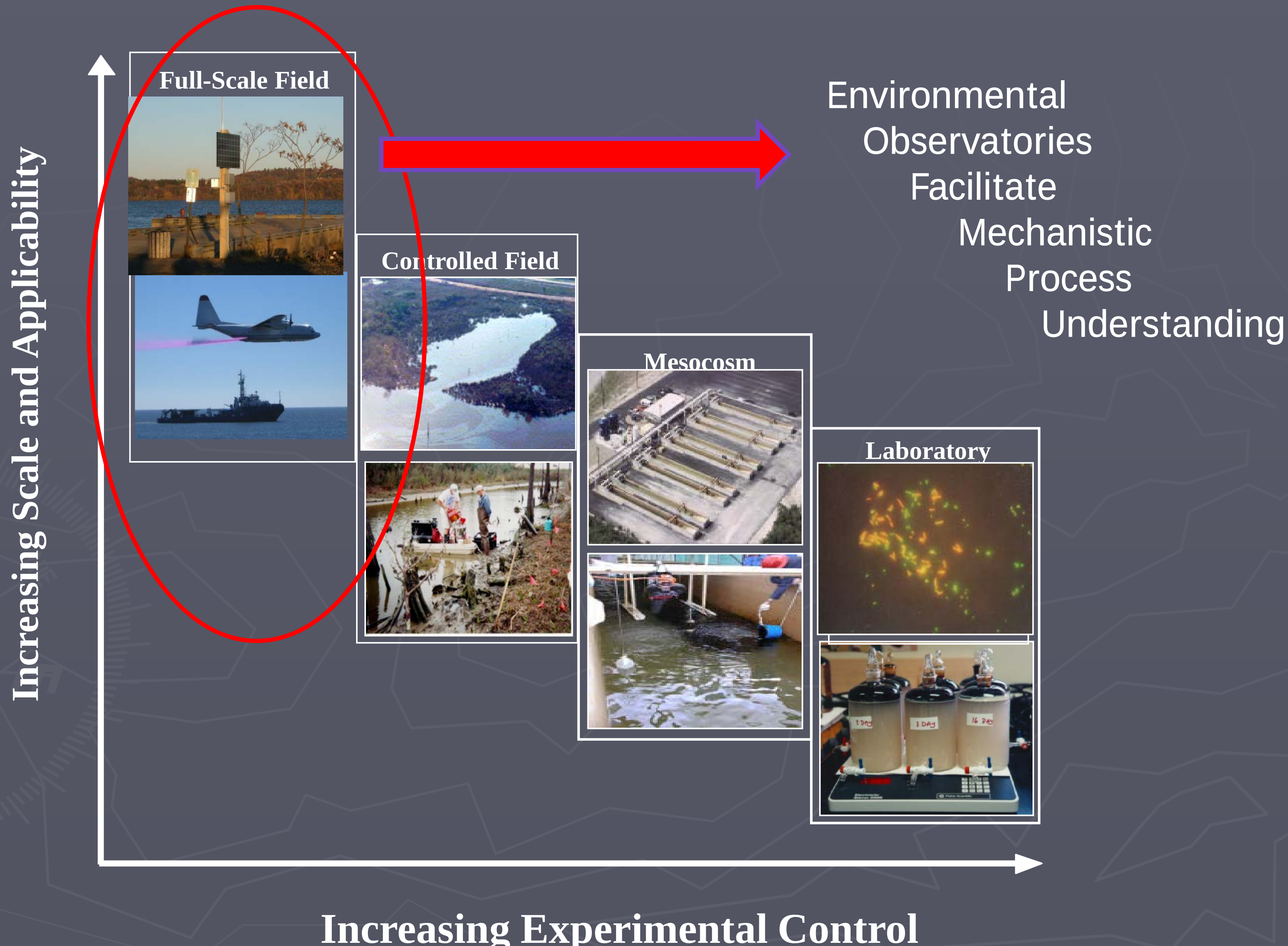


Spill Event

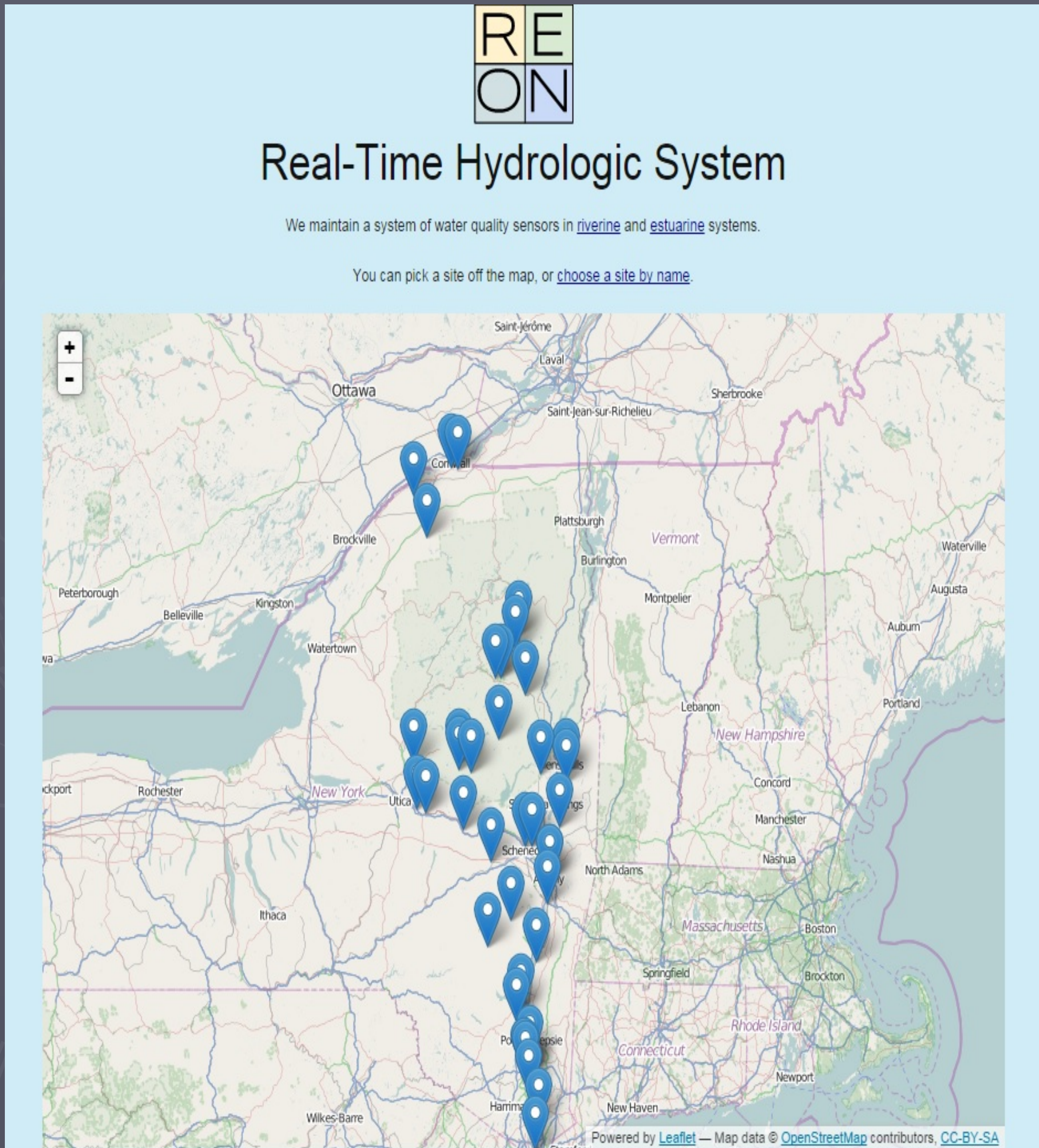
Suspended Particle Temporal-Spatial Variability

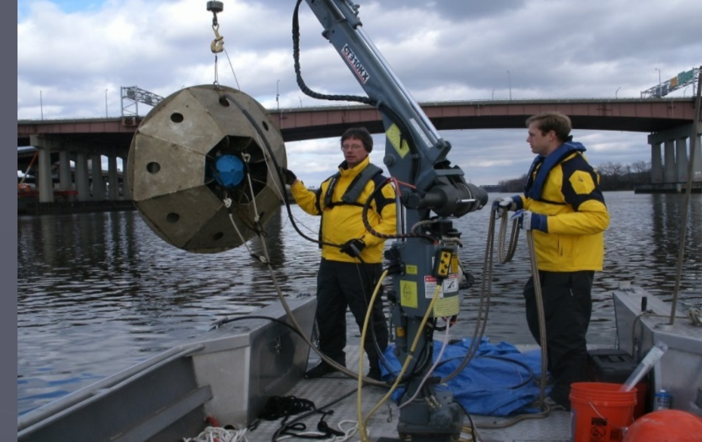


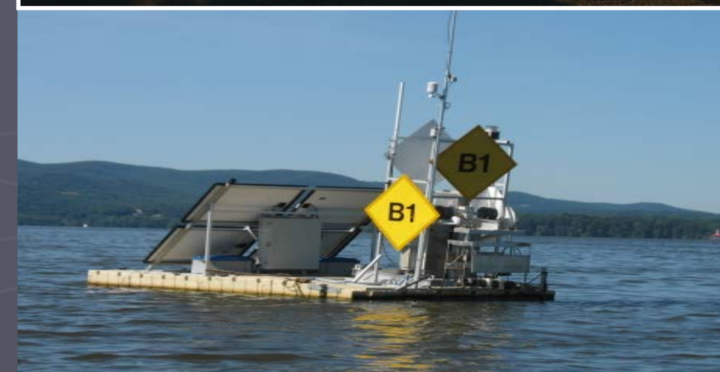
Comprehensive and Fully Integrated Research Program



40+ StationsDeployed in NY Rivers and Estuaries REON II







REON Multiparameter Sonde

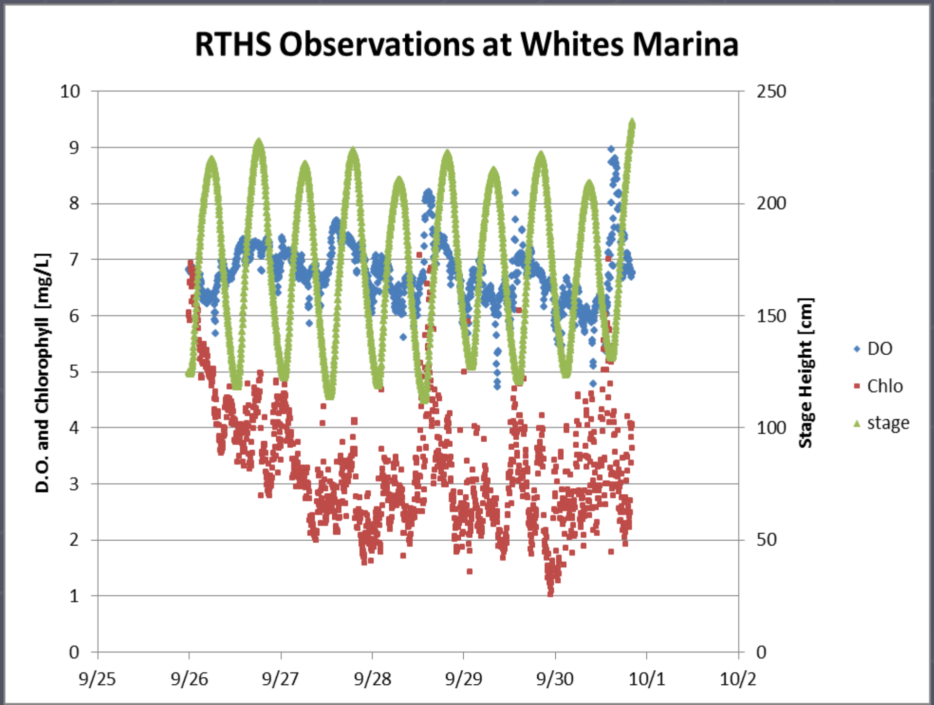
- Parameters
  - pH
  - Dissolved Oxygen
  - Conductivity (salinity)
  - Chlorophyll (optical)
  - Turbidity (optical)
- Design features
  - Low cost
  - Good field performance
  - Ambient light rejection
  - Tested to 100psi submersible depth

Low Cost Water Quality Sonde

- Multi-parameter (pH, DO, salinity, turbidity, chlorophyll)
- Water quality sonde deployed near New Hamburg, NY.
- **Total cost ~$700**

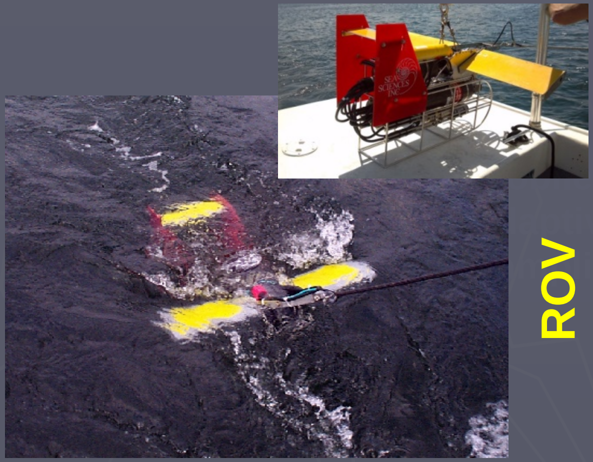
Design Features

- Low Cost
- Good Field Performance
- Customizable Design
- Ambient Light Rejection
- Tested to 100 PSI (200 feet)
- "Plug and Play" with RTHS for Autonomous Monitoring



SENSOR Deployment Platforms

Moored Robotic Platform



ROV

Autonomous Under water Vehicle (AUV)

Acoustic Sensors

HF-radar deployment at Denning Point

COTS Sensors (i.e. high end research grade)

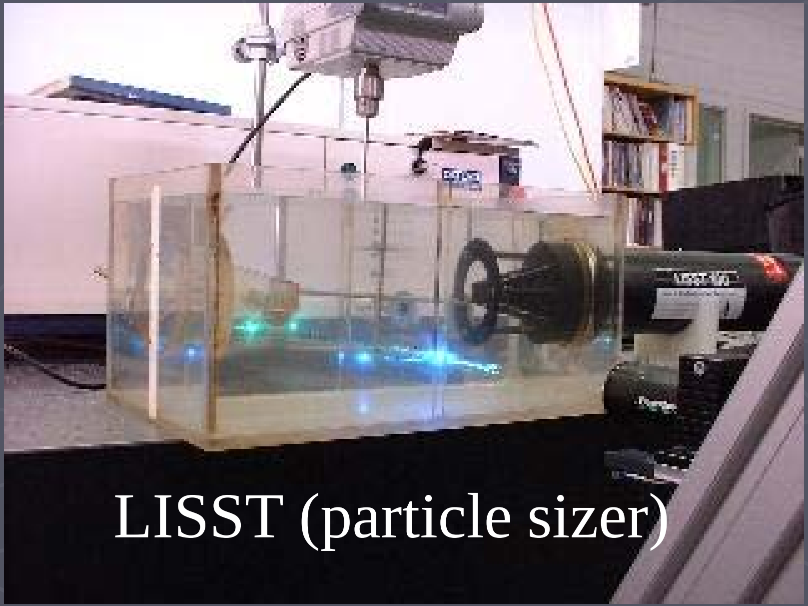
In-Situ Optical Sensors

Fluid Imaging Flow Cytometer

Optode (DO sensor)

FL-3

Laser In-situ
Scattering Transmissiometer



LISST (particle sizer)

Nutrient analyzer

Images from New FlowCytometer NSF-MRI Project


185


627

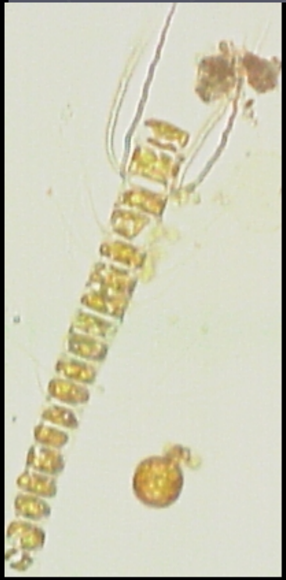

62


149


286


198


218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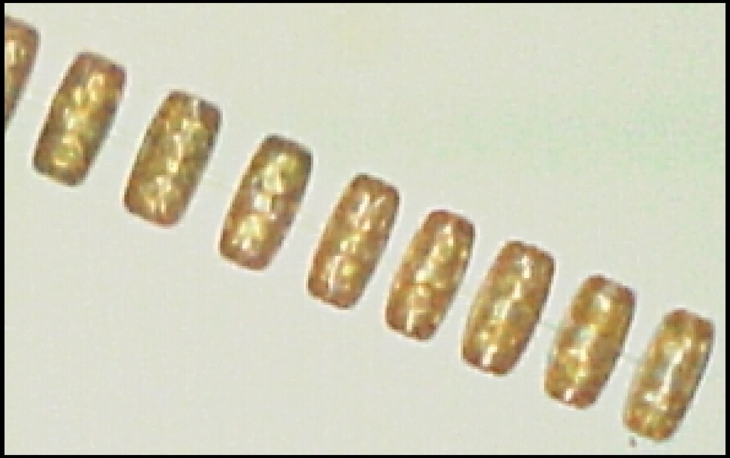
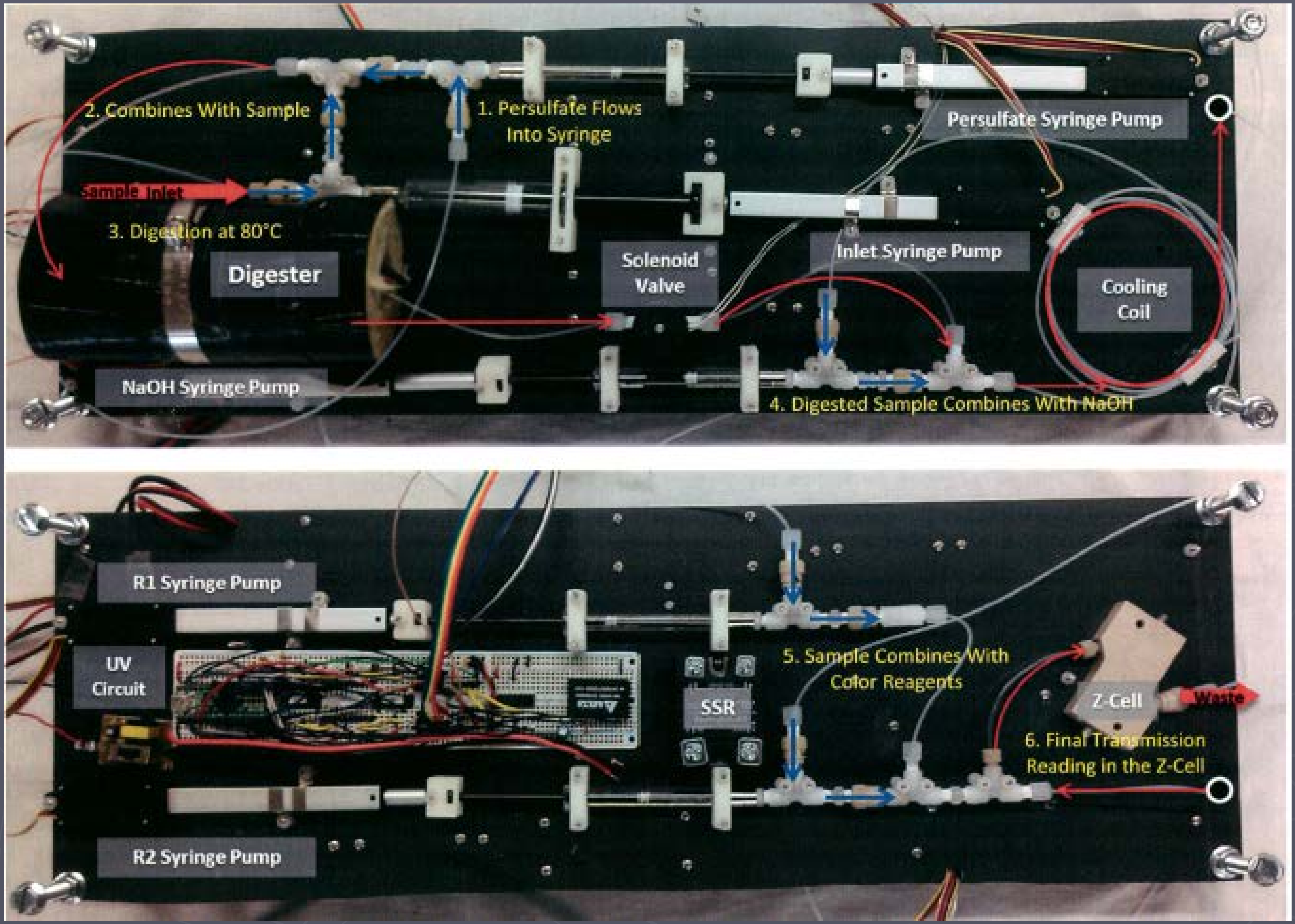
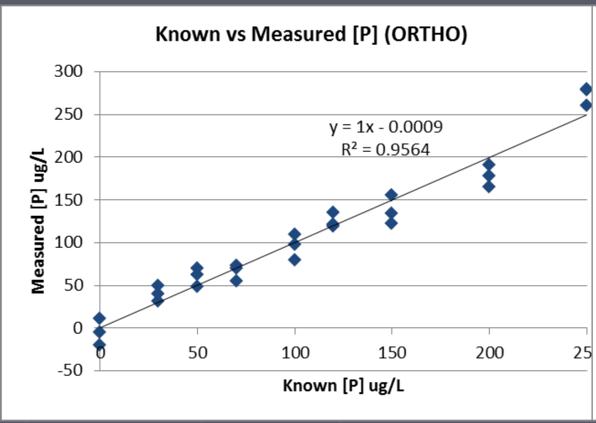


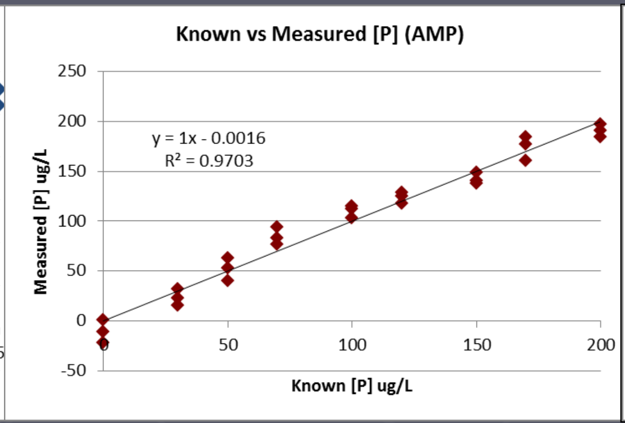
In-situ Real-time Total Nutrient Sensor



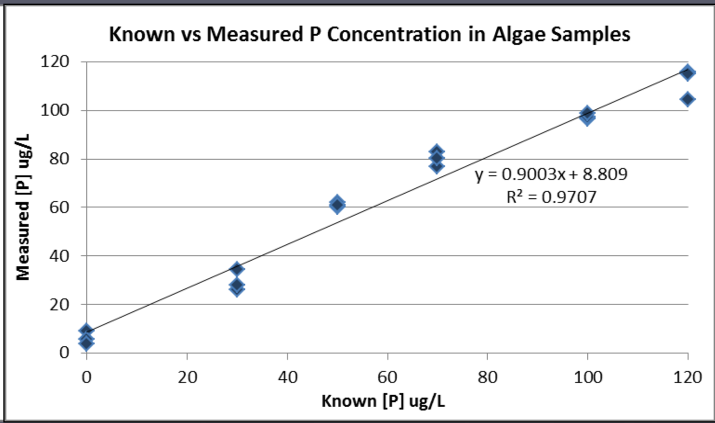
Calibration Curves



Inorganic Phosphorus



Organic Phosphorus



Algae Samples

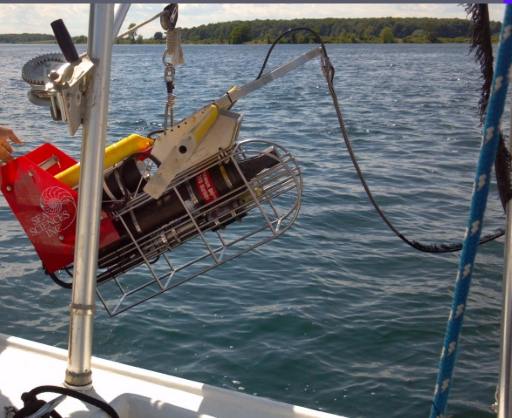
Forms of Phosphorus

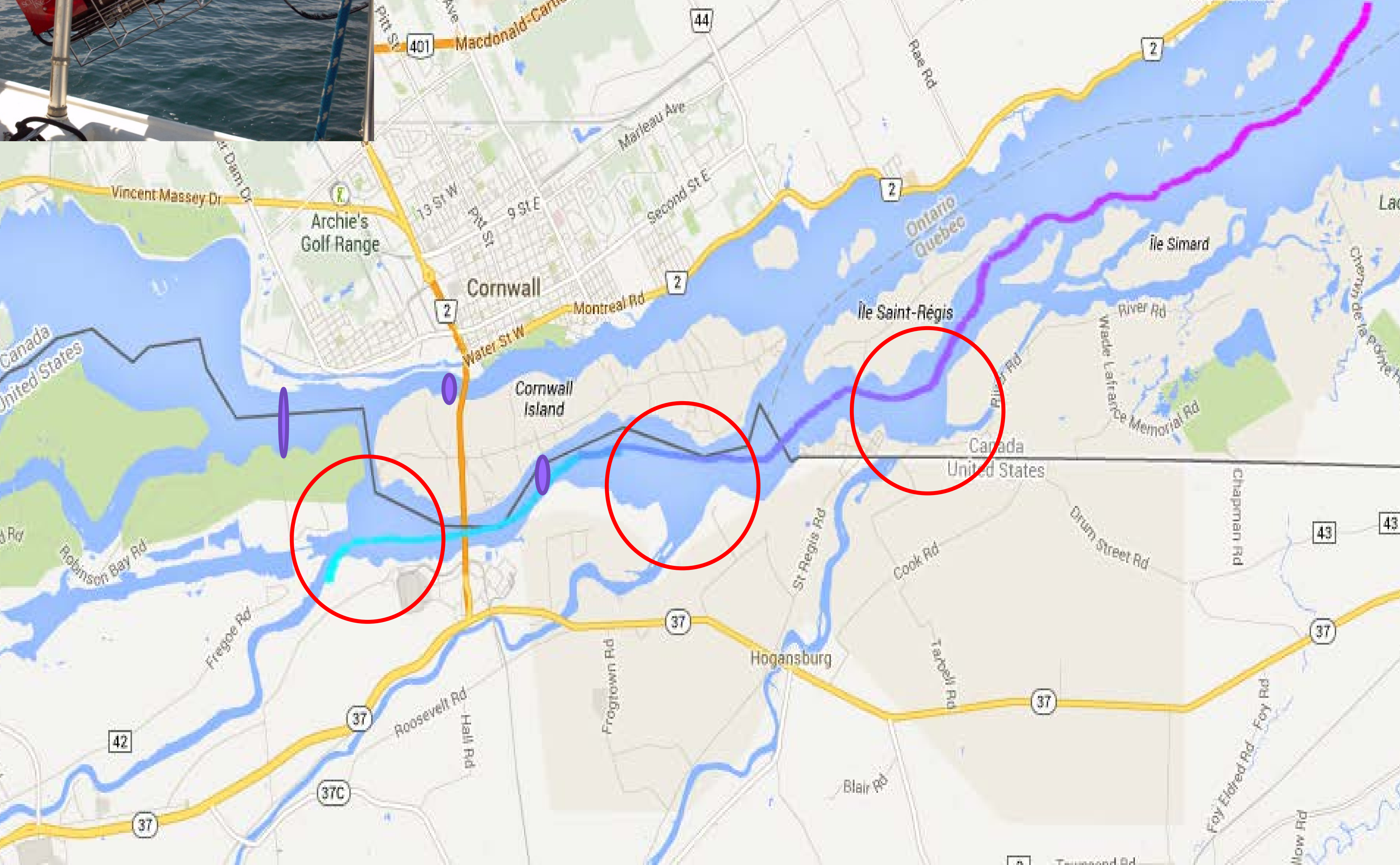
- <u>Soluble Reactive Phosphorus:</u> mostly inorganic phosphate (PO_4^{3-})
- <u>Soluble Unreactive Phosphorus:</u> organic molecules and chains of inorganic phosphates (polyphosphates)
- <u>Particulate Phosphorus:</u> phosphates bound by solids such as algae or detritus
- **<u>Total Phosphorus</u> = All filterable and particulate phosphorus**

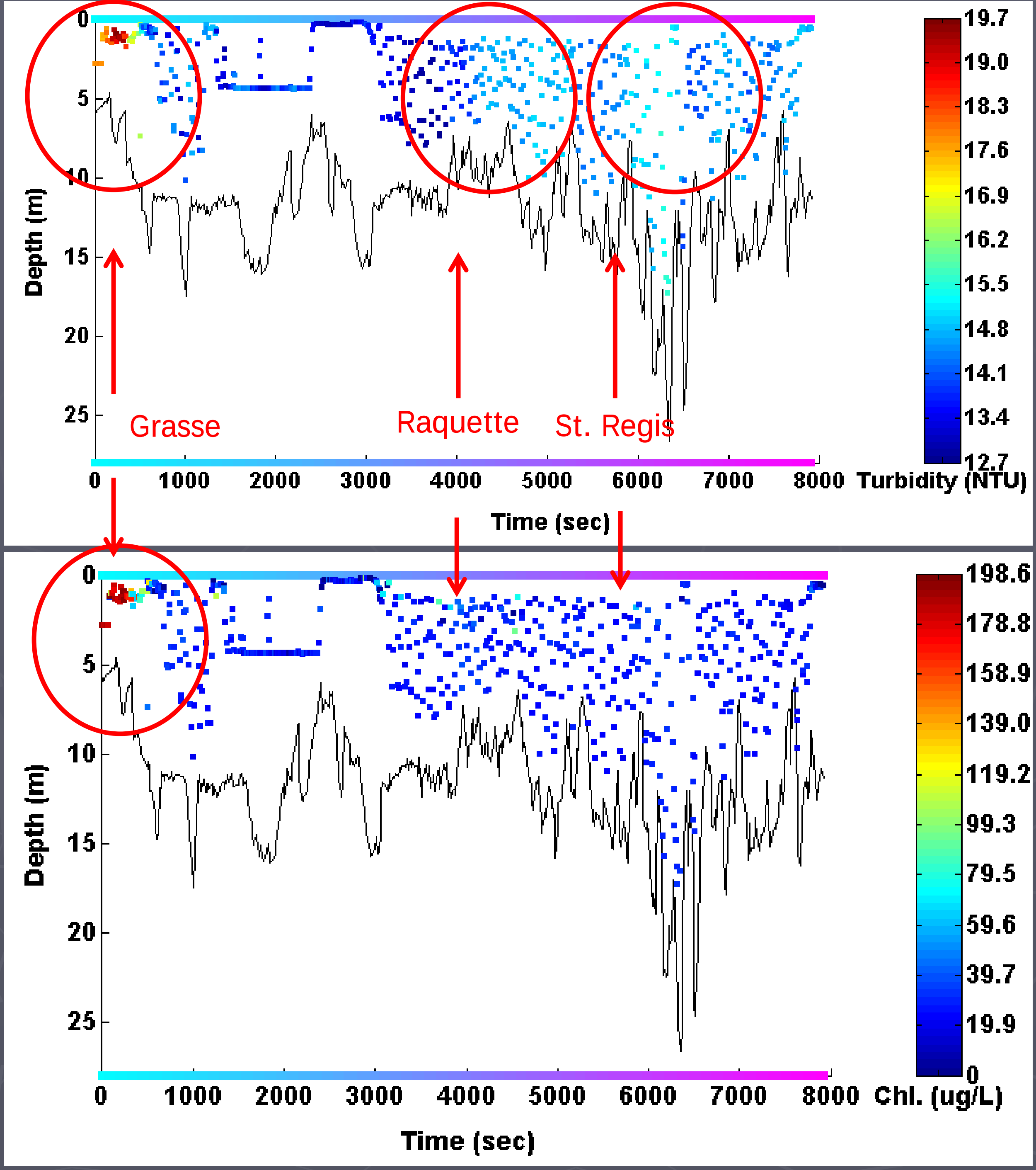
Lake Sturgeon Spawning Habitats

- Velocity 0.1-1.5 m/s
- Depth 0.1-5 m
- Coarse cobble and rubble substrate
  - Void of subaquatic vegetation
- Substrate thickness 0.3 m
- Current breaks (i.e. eddies) are important
- Distance to staging areas (i.e. pools) are important.
- Naturally variable flow regimes are critically important
  - Movement upstream during high flow
  - Movement downstream during decreasing flows
- Water quality-
  - D.O. > 7.5 mg/L
  - Abnormally high supersaturation can have adverse lethal effects on embryos and larvae

St. Lawrence River Transect Rout







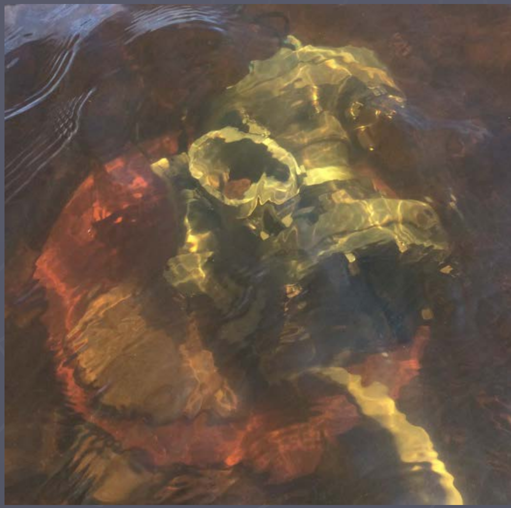
- Higher turbidity observed in Grasse relative to mainstream
  - tributaries contribute particle load
- High turbidity associated with elevated Chlorophyll levels in Grasse river
  - Tributary contributions to biological productivity

Real Time Hydrologic Station for Real Time Monitoring

Base Station

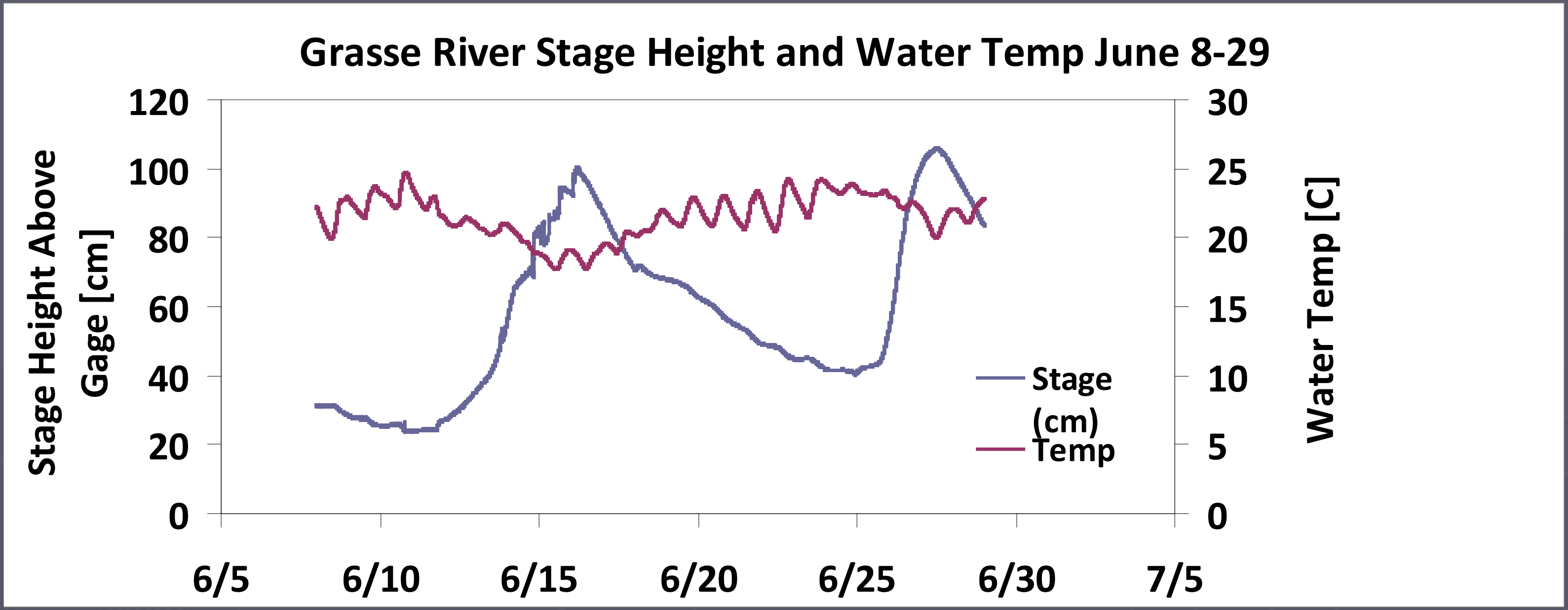
- Self contained
- Cellular data coms
- Web access

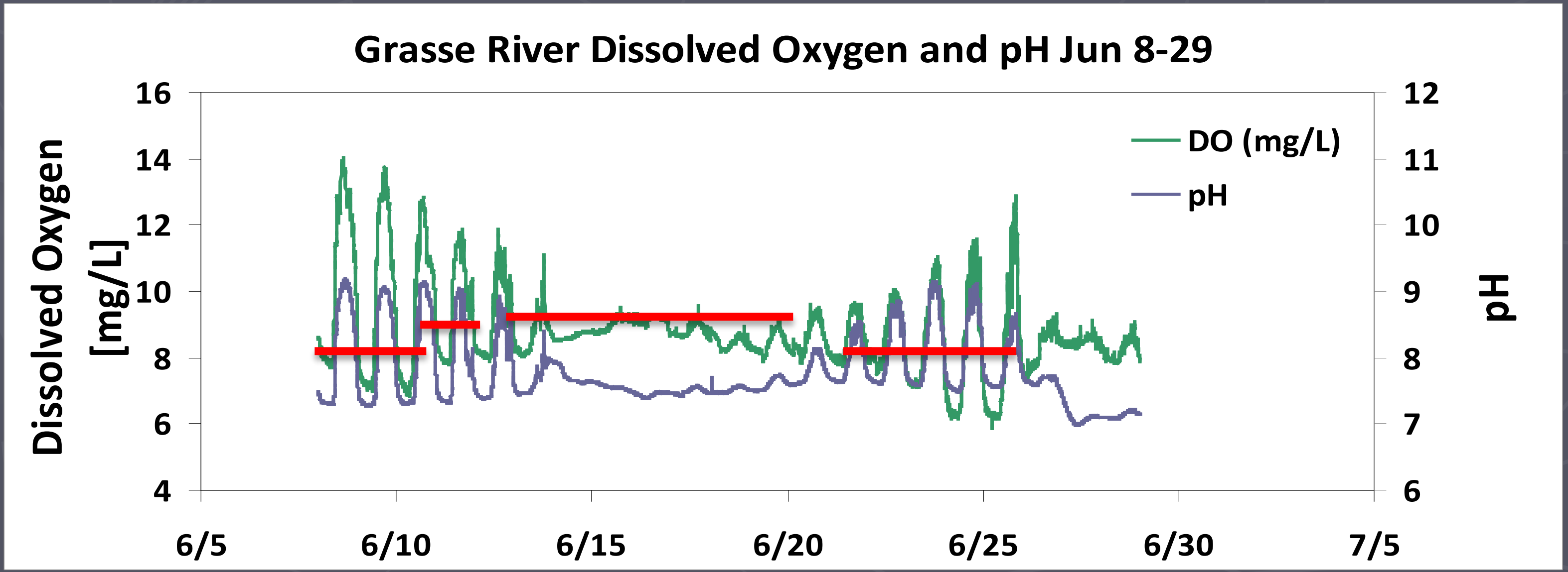
Stream Gage and Water Quality



Left- Elevation survey for stage gage
Above-Stage gage and sonde deployed with 100 lbs. anchor

Temporal variation of habitat conditions at the monitoring site





Example 2: Characterization of Contaminated sediment transport

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**

Atlantic Sturgeon

Historical Threats

A moratorium on all US commercial harvest was established for Atlantic sturgeon in 1997- classified as an endangered species 2012, Populations were unable to rebound because of a loss of spawning grounds and reduced water quality

Current threats include:

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

Habitat

•Spawn in freshwater in the spring and early summer

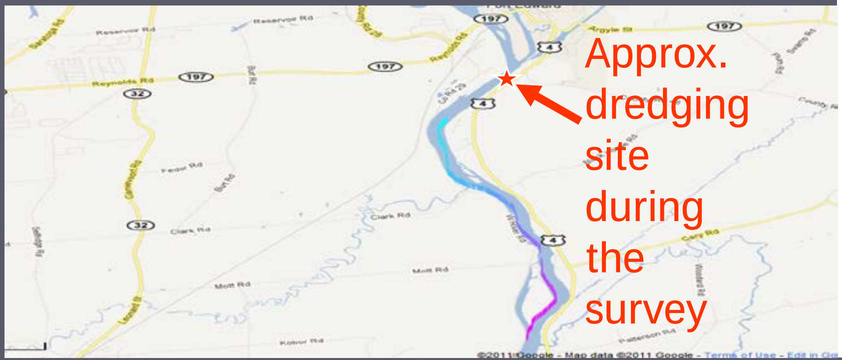
•Spawning occurs in moderately flowing water (46-76 cm/s) at the salt front.

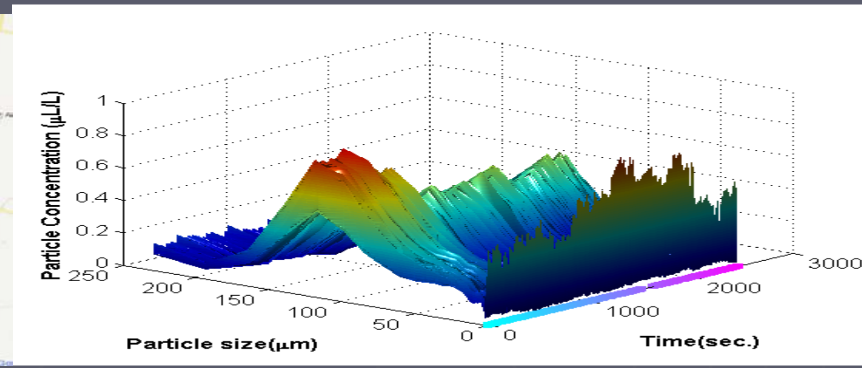
•Larvae use benthic structure as refuges and Sturgeon feed there as well

•Migrate into estuarine and marine waters where they spend most of their lives.

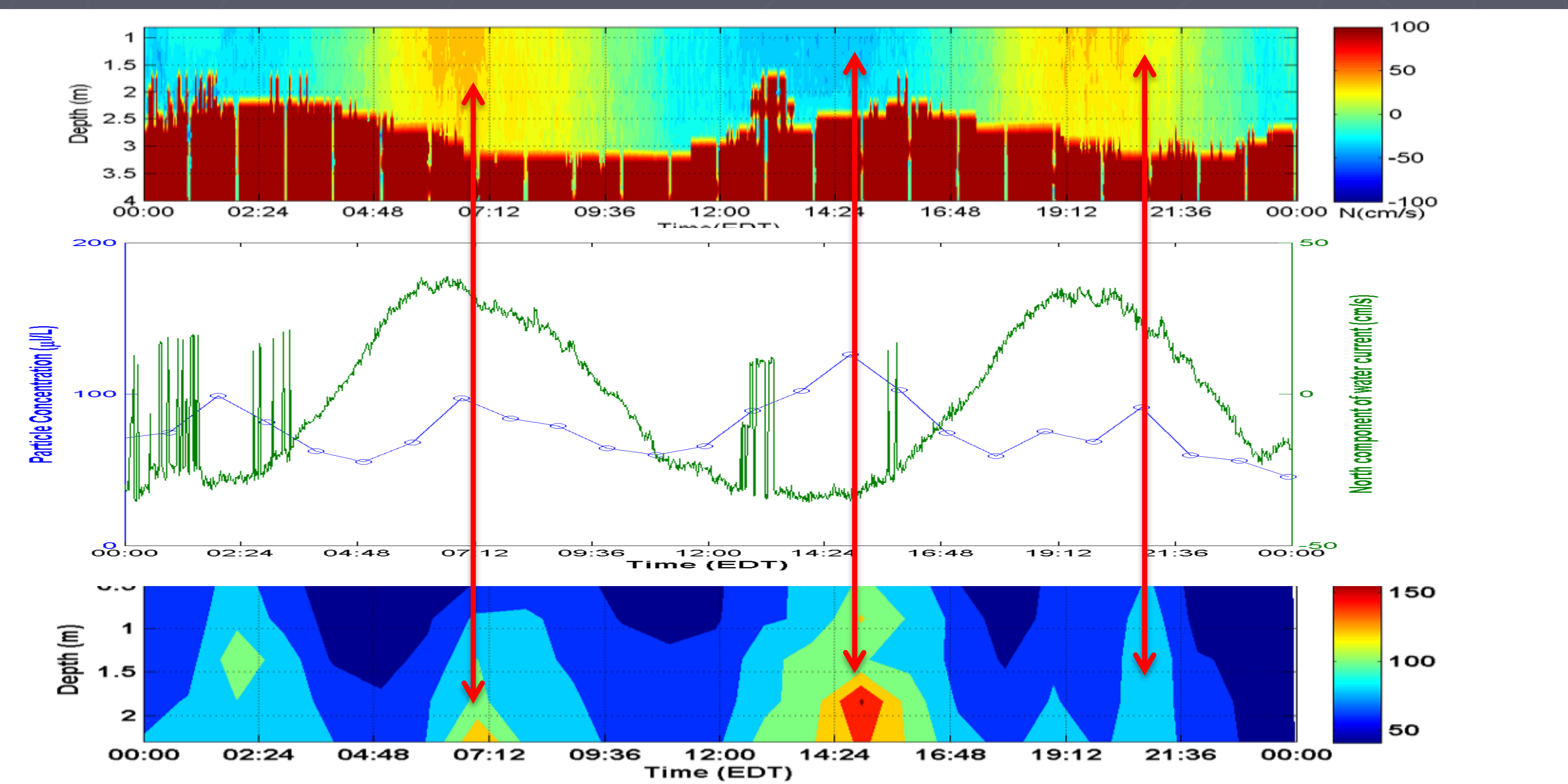
•Juveniles usually reside in estuarine waters for months to years and are benthic feeders

Mobile platform survey upper Hudson data





Robotic platform survey Lower Hudson data

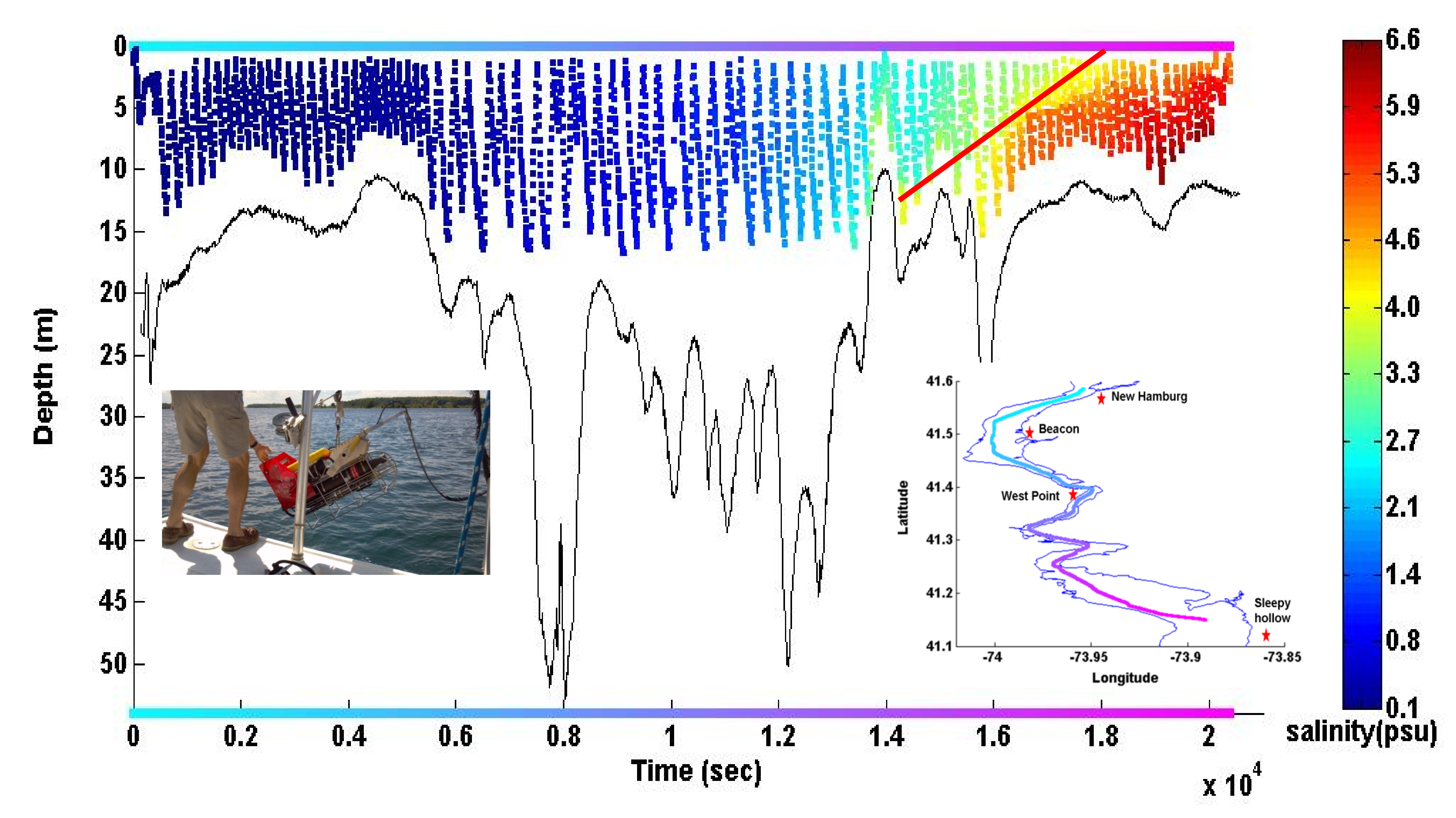


Velocity

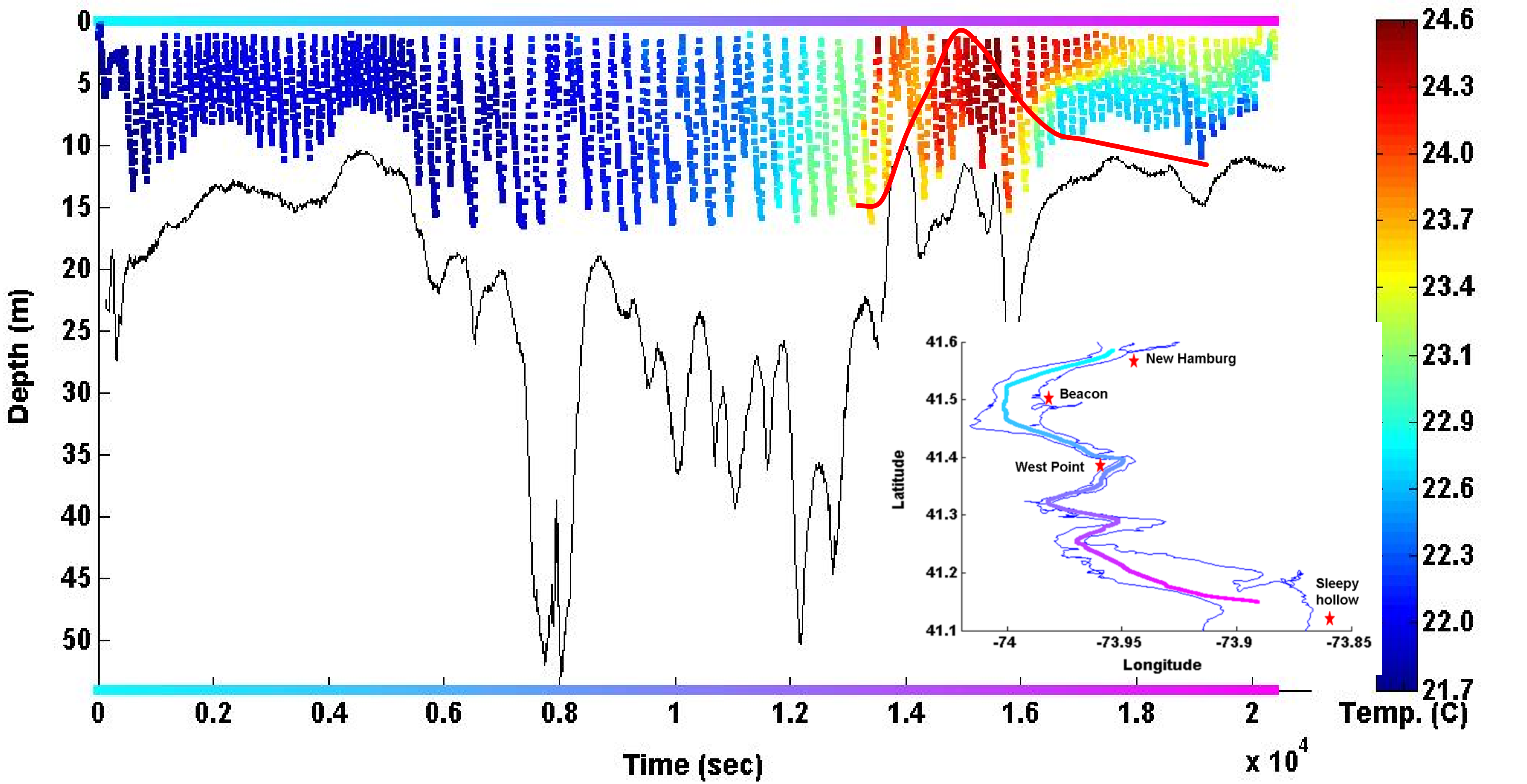
Velocity & Particles

Particles

Characterization of salt wedge in Hudson River, September 24, 2009



Spatial variation of water temperature along the Hudson River and Estuary on September 24, 2009



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.

CONCLUSIONS

- Appropriate high frequency, high resolution, in situ, near real time, sensor networks are critical to assess environmental quality and impact of anthropogenic activity

- Temporal sampling has to be 10X greater than the critical inherent frequency and spatial sampling must be adequate to characterize environmental gradient

- Sensor networks are necessary for improved understanding of habitat characteristics and changes, critical for restoration efforts and regulatory compliance.

Environmental Observatories (Yes or No)

Should we do it????

Is the time right??

Is it Cost prohibited ???

Will it be Effective???

Will it drive WQ criteria and standards??

Will it aid Compliance & Enforcement ??

Will it ultimately Protect the Environment??

If time then questions???

Thanks!!!

- Capital investments
  - Multiple data nodes necessary for spatial coverage
    - Higher resolution = higher station count = higher network capital investment
  - State of the art instrumentation = state of the art instrumentation cost—
- O&M
  - Operational costs extend for duration of network lifetime

    (O&M=$\int_0^{\infty} Kccm * Capital\ cost\ dt$), Kccm≈1/3)
  - With this percentage of capital costs mutiplier can replace the entire network every 3 years ??
  - Funding sources generally prefer Capital Projects
  - O&M costs viewed on indirect costs