What are we collecting and are we collecting the information we need?

Brian Bergamaschi, Bryan Downing, Scott Nagel, Tamara Kraus, and many others

USGS
science for a changing world

What are the goals of monitoring?

Examples from RMP nutrient monitoring design:

- How do concentrations of nutrients and effects vary spatially and temporally?
- What are the loads from tributaries to the Delta?
- What are the sources and loads of nutrients within the Delta?
- Which factors in the Delta influence the effects of nutrients?
- What are the types and sources of nutrient sinks within the Delta?

What are the goals of monitoring?

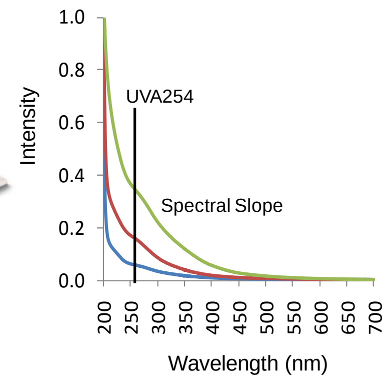
- What is the needed accuracy of external and internal load-monitoring assessments?
- What is the time over which loading assessments are relevant to environmental effects? Annual, seasonal, monthly, daily?
- What level of change needs to be detected? Over what time period?
- To what spatial resolution do internal sources and processes need to be resolved?

HD HIGH DEFINITION monitoring nD

Continuous, real-time, high-frequency, flux-based, multi-parameter measurements of ecosystem indicators and biogeochemical processes at fixed stations

Integrated with intermittent spatial assessments

An *ongoing* revolution in field instrumentation, as well as data integration, automated quality assurance, processing and data visualization

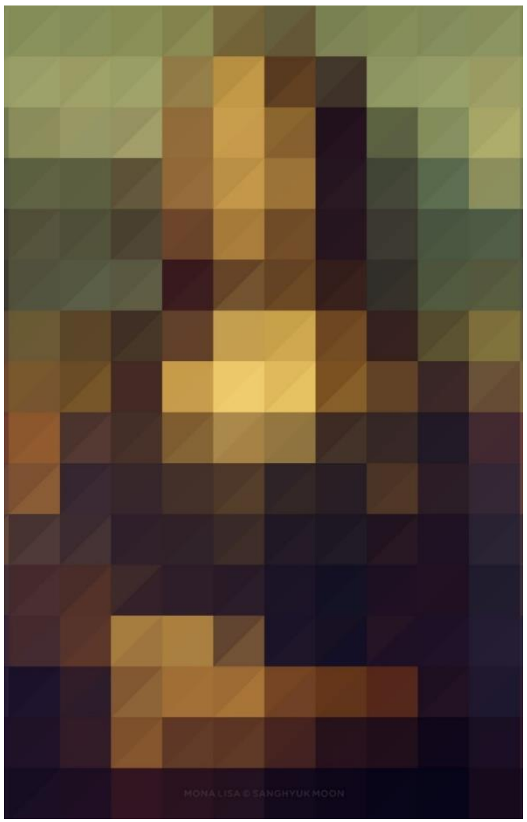


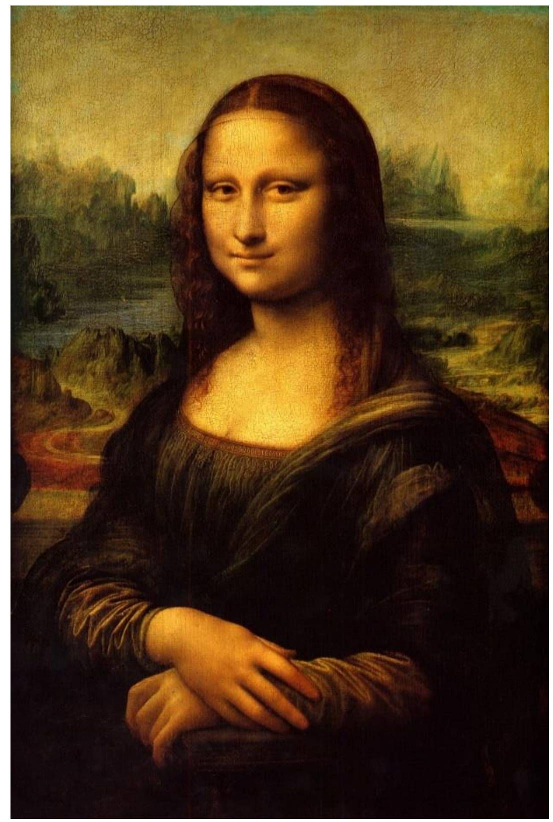
From benchtop…

…to field instrument

Why do we need continuous, flux-based, multi-parameter multi-platform (i.e. HD) measurements?

To see – and quantify – loads, processes and effects

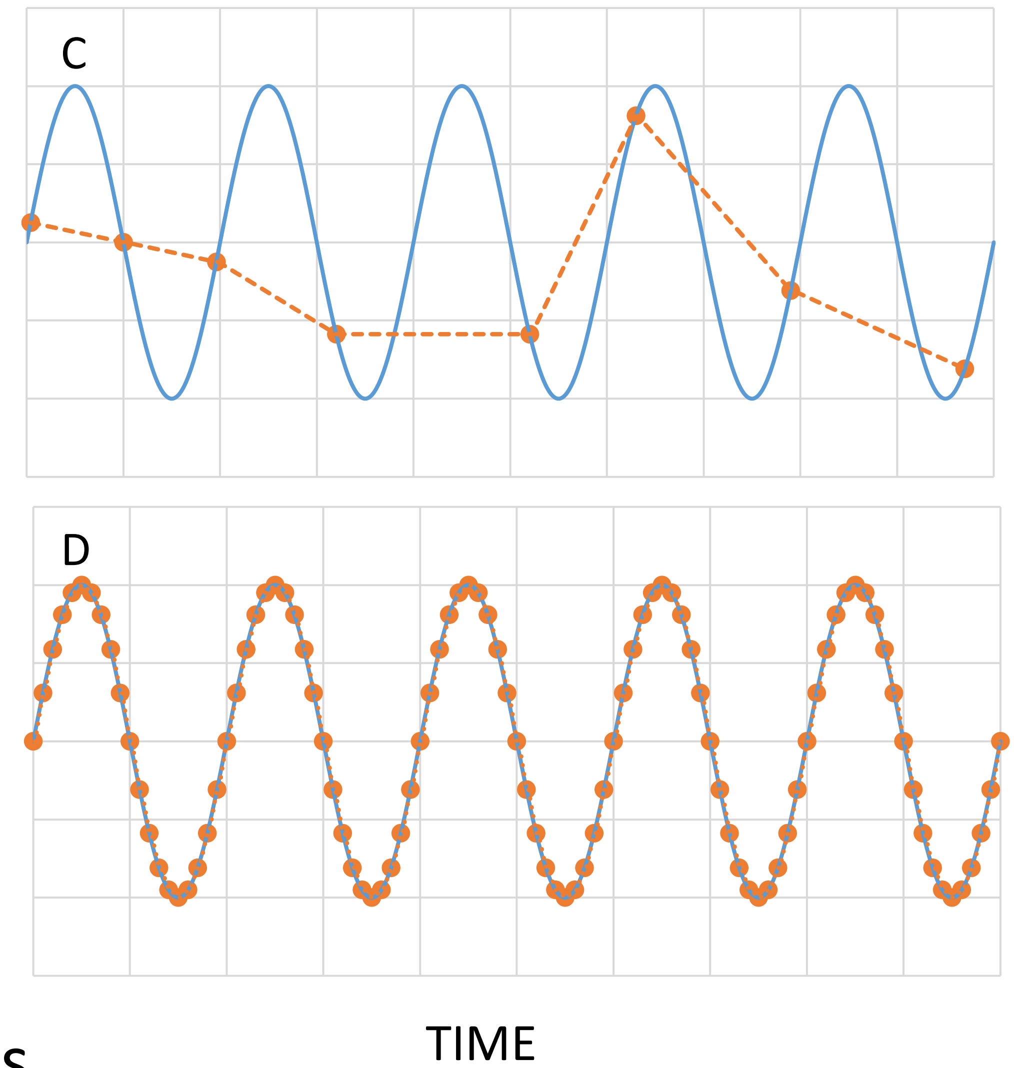




Aliasing

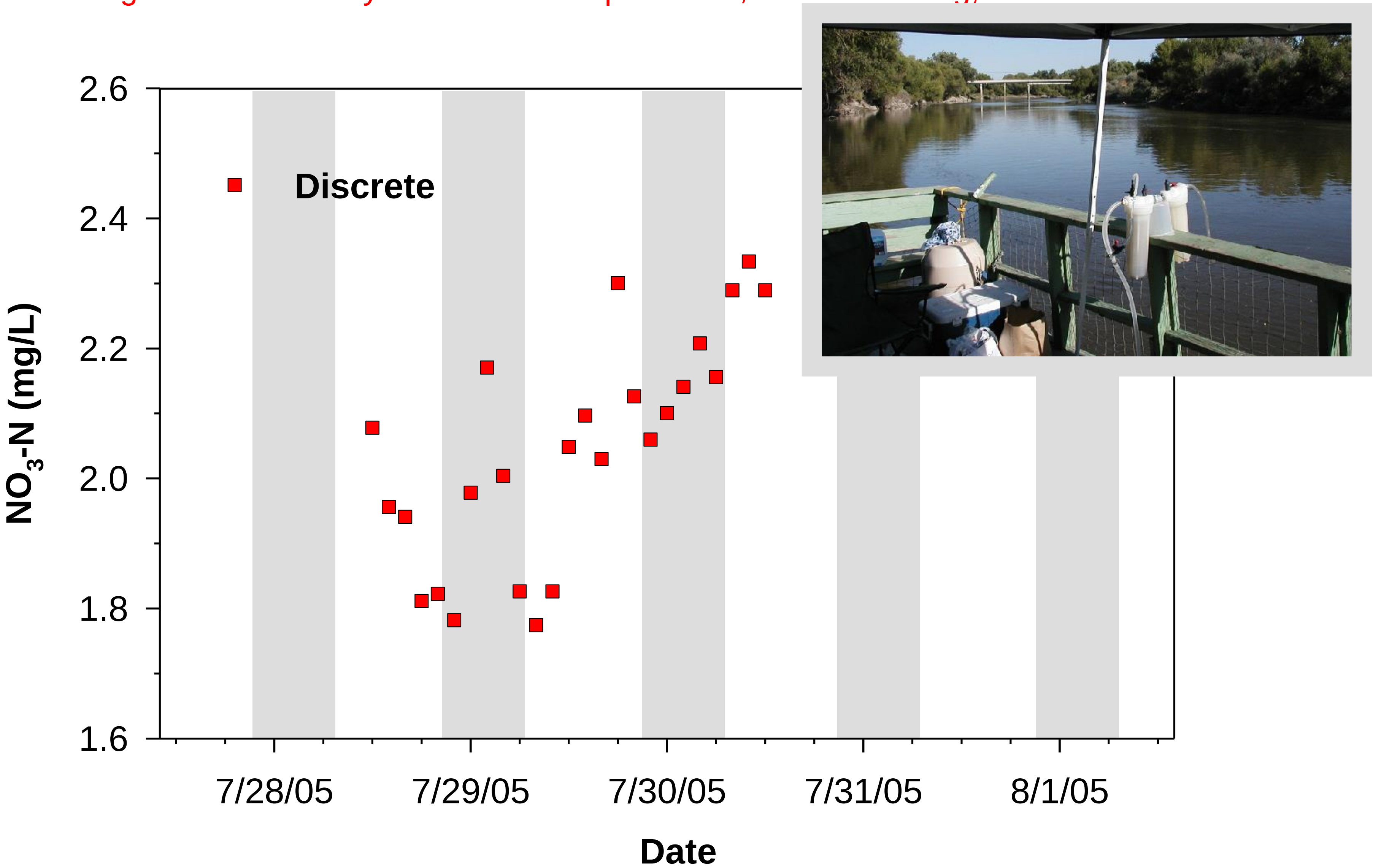
Sampling below the time-scale of change can lead to:

1) Erroneous determination of levels
2) Erroneous determination of changes over time
3) Missing real changes



Nitrate Variability – San Joaquin River

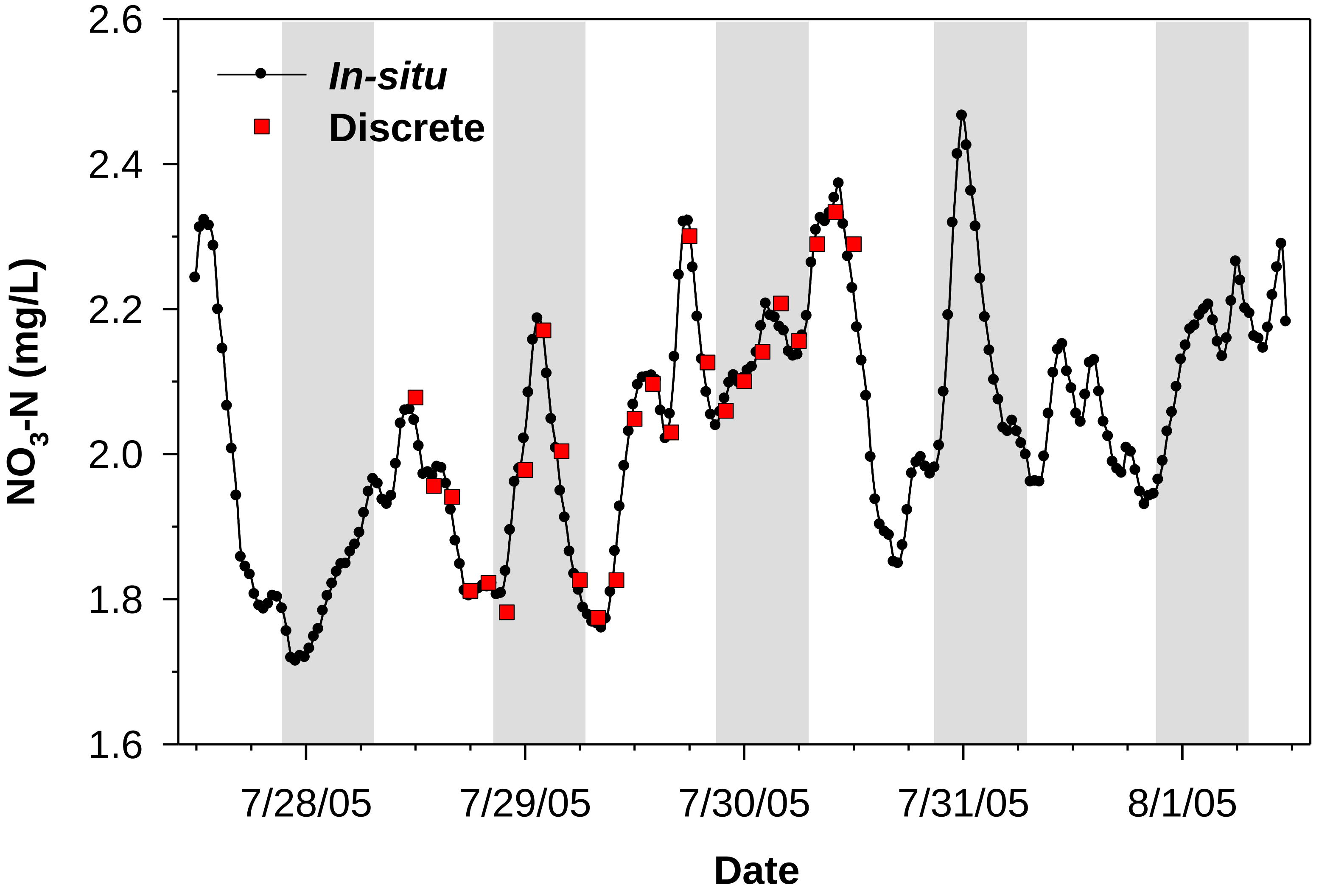
Assessing nitrate variability in the San Joaquin River, Crows Landing, CA



Pellerin et al., 2009

Nitrate Variability – San Joaquin River

Assessing diurnal nitrate variability in the San Joaquin River, Crows Landing, CA
(Satlantic ISUS nitrate analyzer)

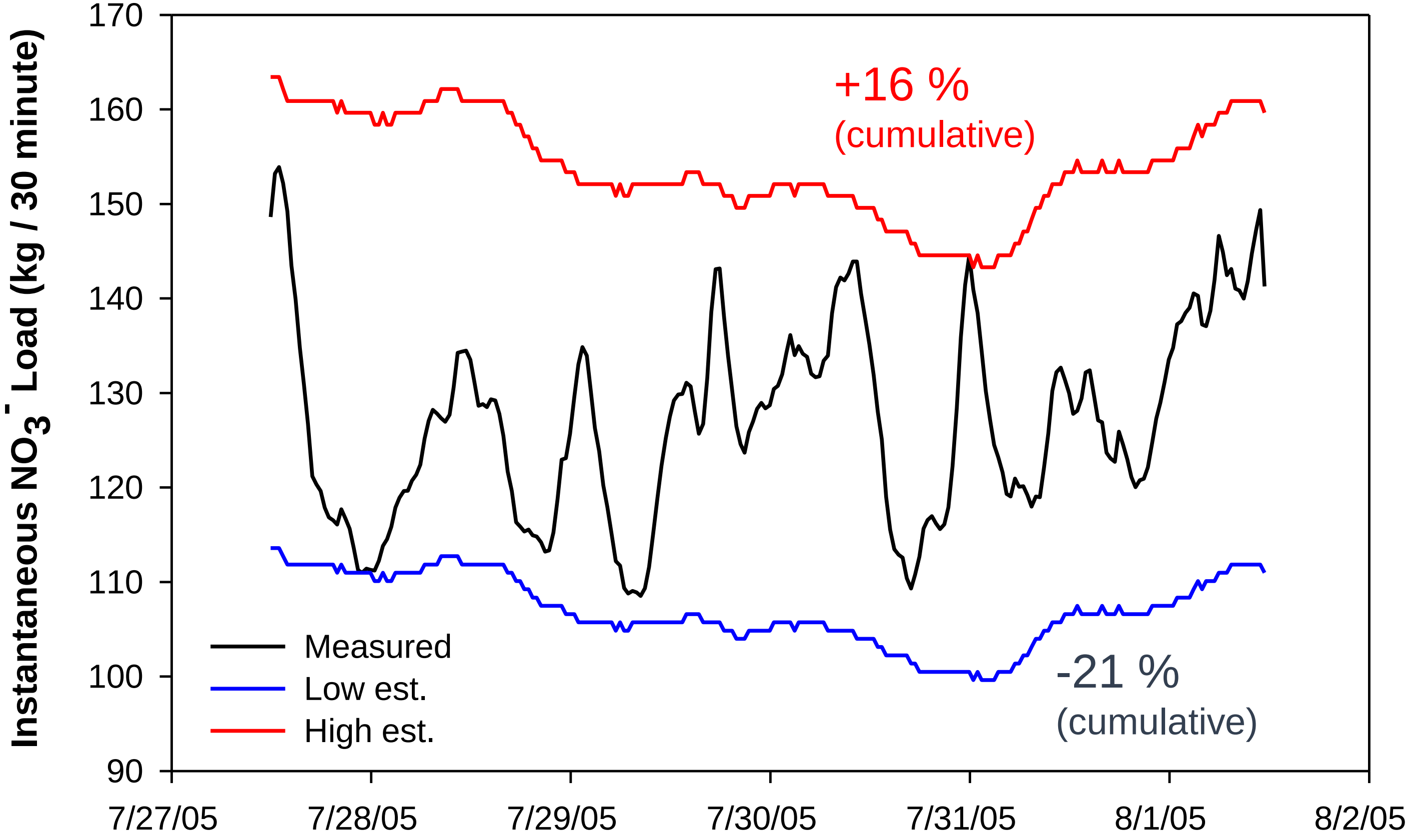


Pellerin et al., 2009

Nitrate Loads – San Joaquin River

Difference in instantaneous and cumulative nitrate load at Crows Landing during the study period. **Daily loads were -23 to +30 % relative to measured load** using continuous data.

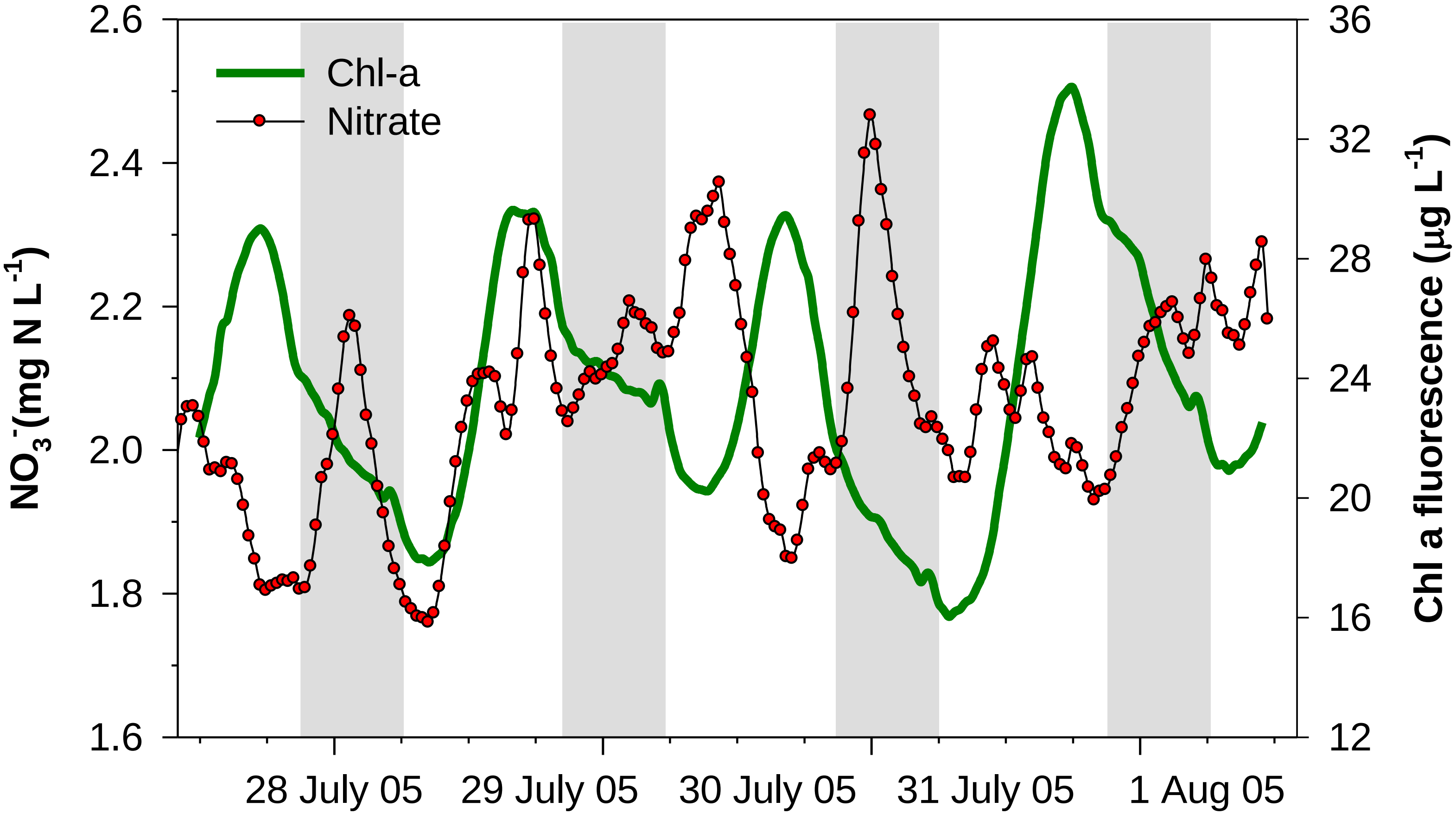
	Daily Load (kg nitrate / day)			% Difference	
	Measured	Low est.	High est.	Low est.	High est.
28-Jul	5875	5305	7631	-10	30
29-Jul	6563	5064	7284	-23	11
30-Jul	6160	4956	7130	-20	16
31-Jul	6047	5024	7228	-17	20



Pellerin et al., 2009

Drivers of nitrate variability - SJR

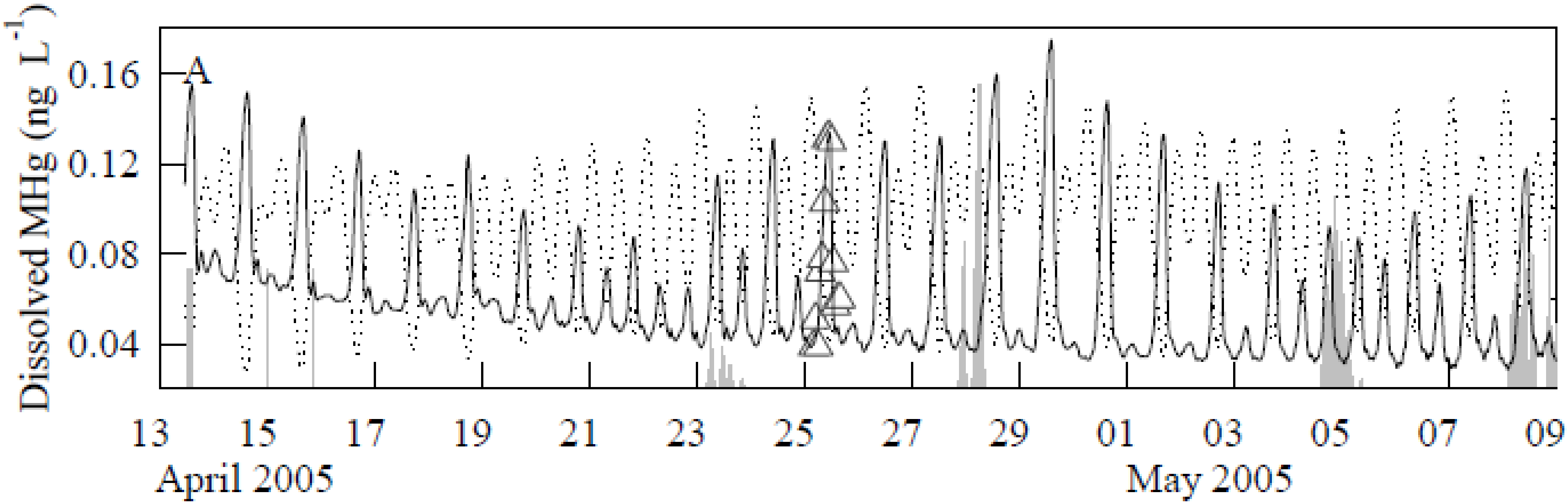
Combination of discrete and in situ data show
high biological activity in the SJR



Pellerin et al., 2009

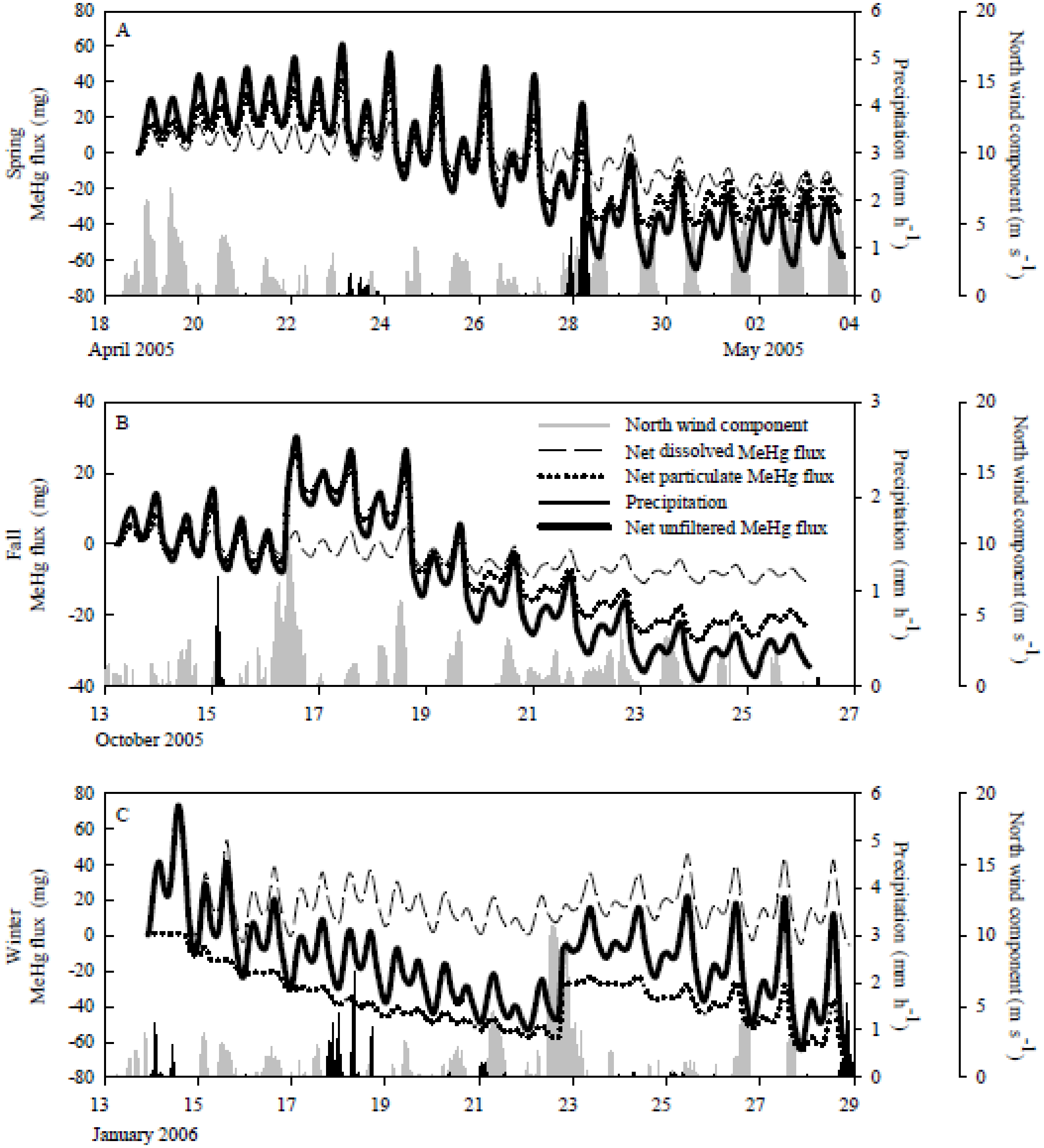
RESOLVE TIDAL PROCESSES:
Example: Methylmercury export

Proxy measurements for high resolved MeHg flux from a tidal wetland, Browns Island, CA



Bergamaschi et al., *2011,*

Methylmercury fluxes and yields



YIELDS:

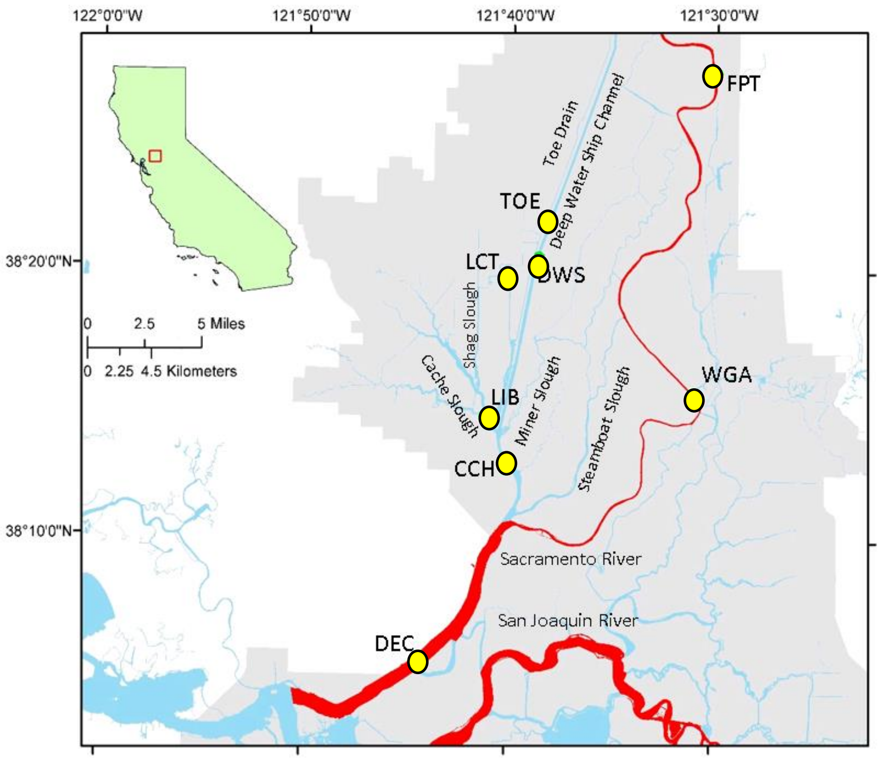
2.5 μg m^{-2} yr^{-1}

4-40 times previously published yields

Variation related to:
Tides
River flow
Storms
Wind direction
Barometric pressure
Unknown

Bergamaschi et al., *2011,*

USGS High frequency, real-time, flux based monitoring stations



LOCATION MAP OF USGS BIOGEOCHEMISTRY HF NUTRIENT MONITORING STATIONS IN: 1) SACRAMENTO RIVER AT FREEPORT (FPT) AND WALNUT GROVE ABOVE THE CROSS CHANNEL (WGA); 2) CACHE SLOUGH COMPLEX AT THE MOUTH OF LIBERTY ISLAND (LIB), LIBERTY CUT CHANNEL (LCT) AND THE TOE DRAIN (TOE); 3) SACRAMENTO DEEP WATER SHIPPING CHANNEL (DWS); AND 4), IN THE LOWER SACRAMENTO RIVER AT DECKER ISLAND (DEC).

Site Name	Site Abbreviation	NWIS Station Number
Decker Island	DEC	11455478
Cache Slough	CCH	11455350
Liberty Island	LIB	11455315
Walnut Grove	WGA	11447890
Sacramento River at Freeport	FPT	11447650
Liberty Cut	LCT	11455146
Deep Water Shipping Channel	DWS	11455335
Toe Drain North of Stair Steps	TOE	11455139
San Joaquin River at Vernalis	SJV	11303500

Nitrate
Chlorophyll
Phycocyanin (BGA)
Dissolved organic matter (FDOM)
Dissolved oxygen
pH
Turbidity
Temperature
Conductivity

Phosphate, Ammonium, Other

2014

Freeport Walnut Grove Cache Slough Liberty Island

Nitrate

Chlorophyll

Oxygen

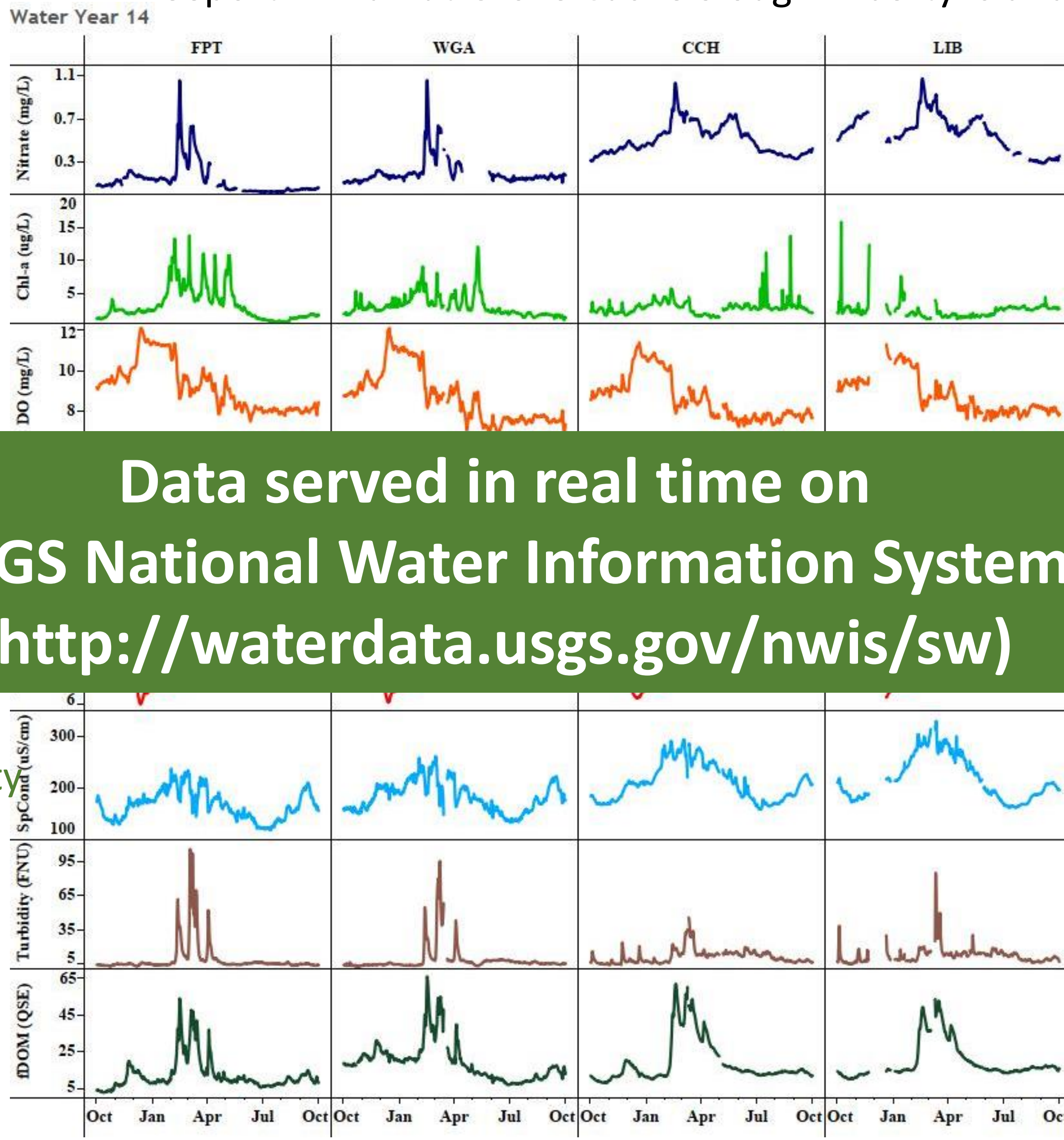
pH

Temp

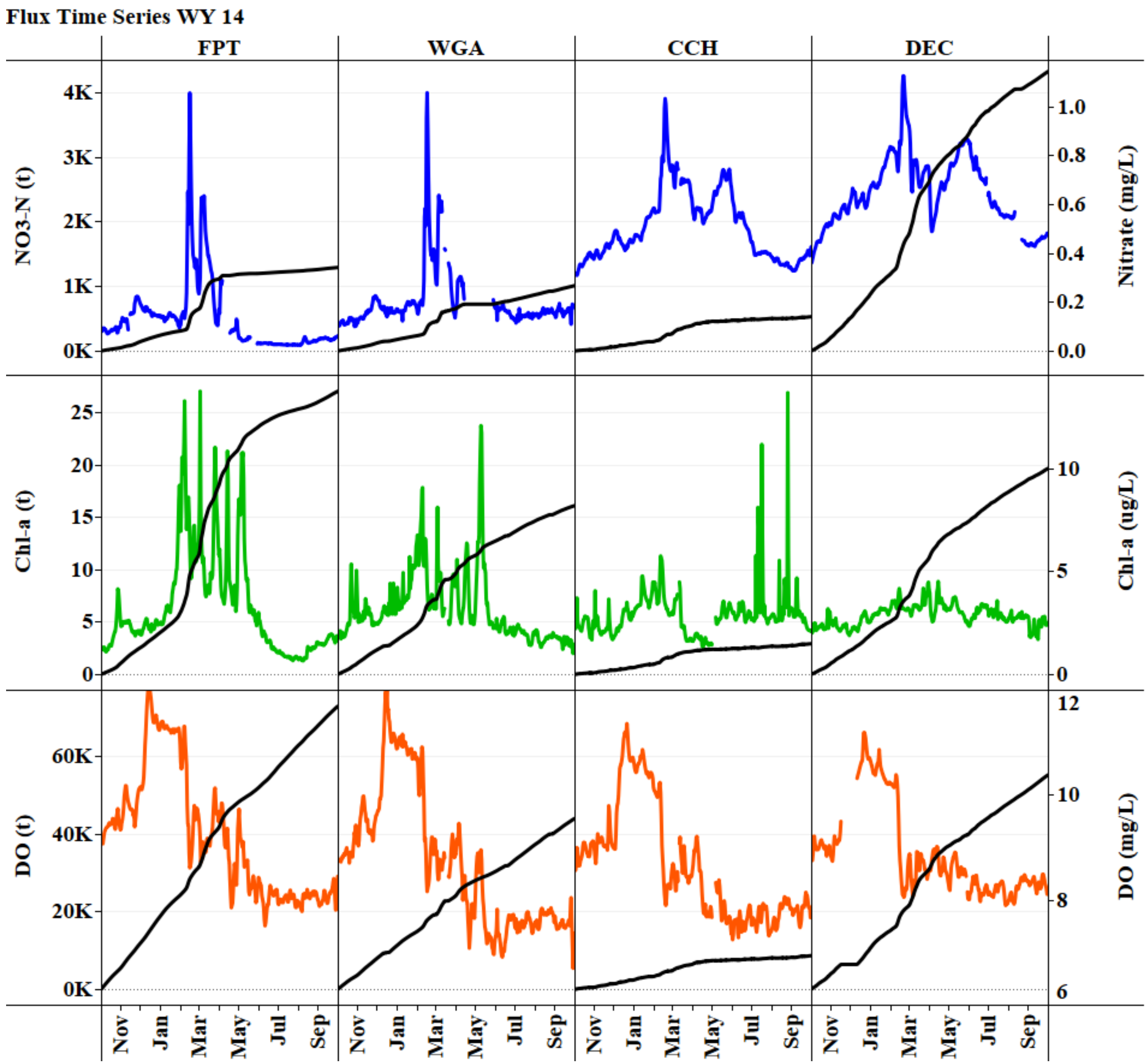
Conductivity

Turbidity

Dissolved Organic Matter

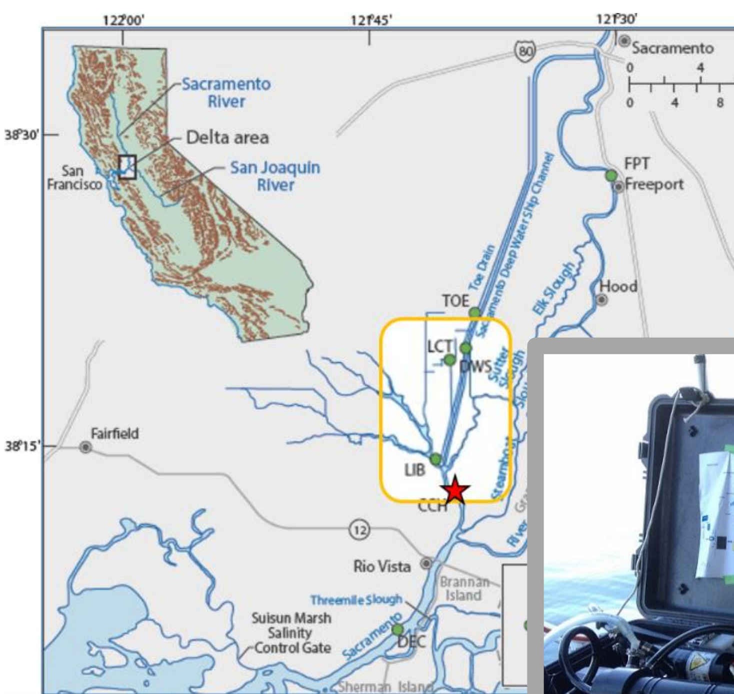


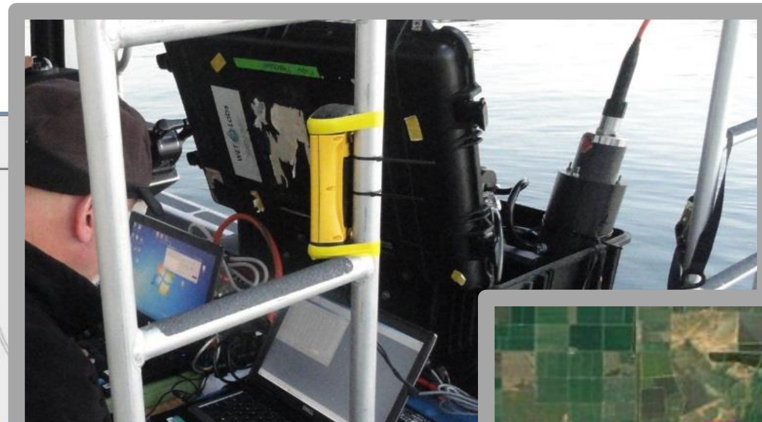
Data served in real time on
USGS National Water Information System
(http://waterdata.usgs.gov/nwis/sw)

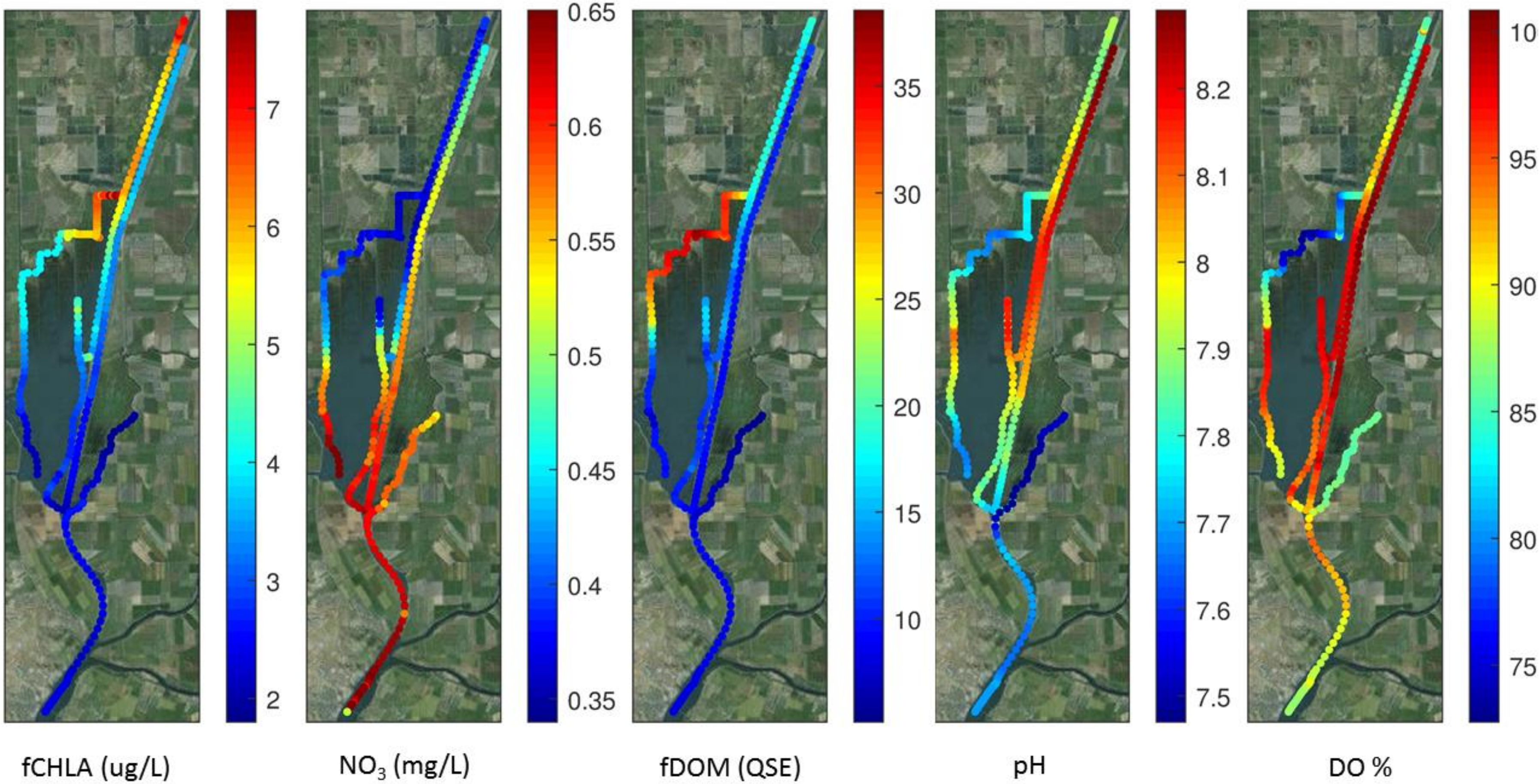


GRAPHS DISPLAYING CUMULATIVE FLUXES (IN METRIC TONNES) CALCULATED FOR EACH STATION, AND ASSOCIATED CONCENTRATION DATA MEASURED AT FREEPORT BRIDGE (FPT), WALNUT GROVE (WGA), CACHE SLOUGH (CCH), AND DECKER ISLAND (DEC) DURING WATER YEAR 2014 (10/1/2013 – 9/30/2014). FLUXES ARE SHOWN IN BLACK FOR NITROGEN (N), CHLOROPHYLL-A (CHL-A), AND DISSOLVED OXYGEN (DO). CONCENTRATION MEASUREMENTS FOR NITROGEN (BLUE), CHLOROPHYLL-A (GREEN), AND DISSOLVED OXYGEN (ORANGE) ARE SHOWN ABOVE.

High resolution spatial assessments - Biogeochemical mapping



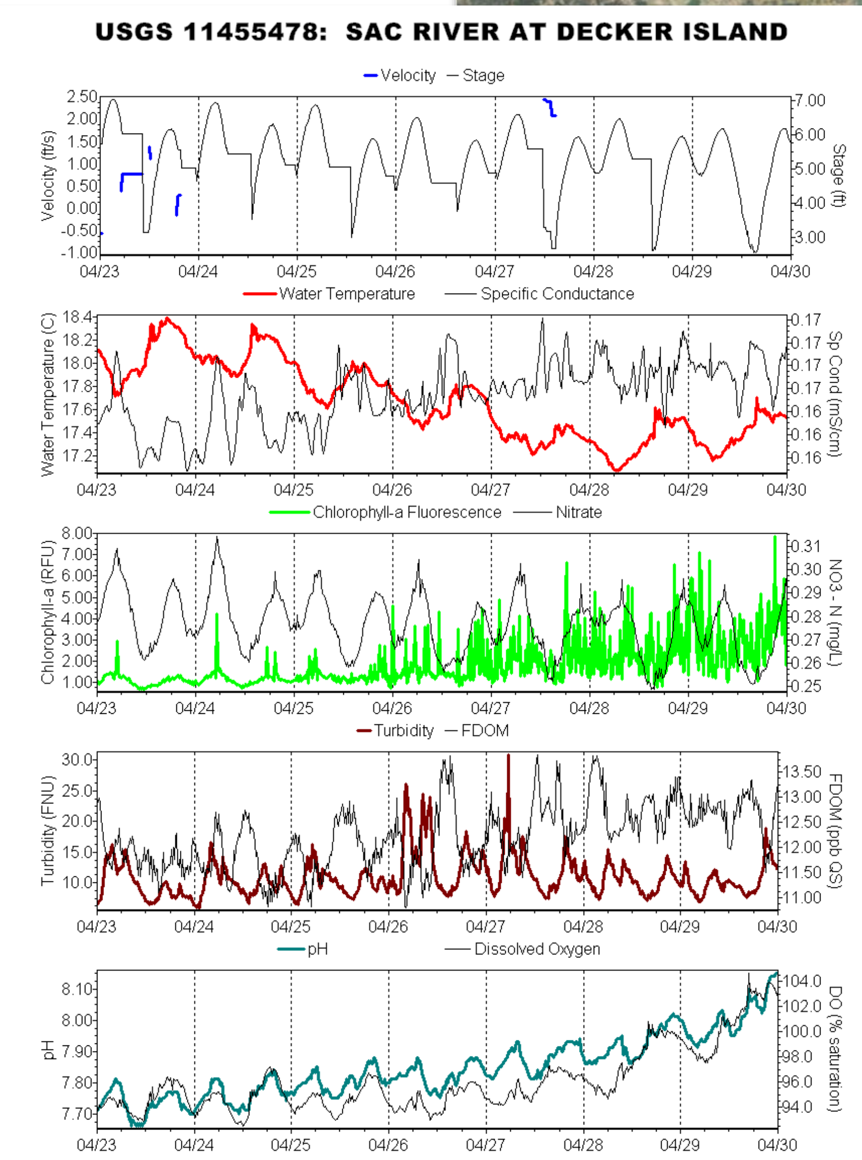


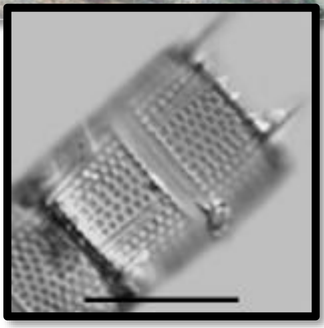


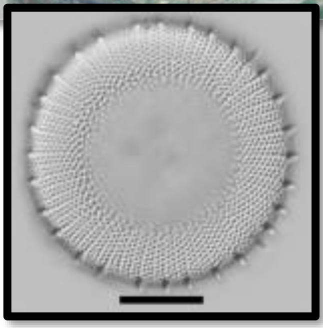
Chlorophyll Nitrate Dissolved OM pH Oxygen

Downing, et al., submitted ES&T

How this all works together in practice







From RT data to RT information

Continuous derivative products

- Biogeochemical rates such as nutrient transformation and utilization rates
- Ecosystem metabolism
- Environmental stoichiometry
- Visual perceptive distance
- DOC
- Suspended sediment concentration

Near Future –

New sensors and techniques

- Phytoplankton basic taxonomy and size
- Bromide
- Mercury, methylmercury

On the horizon –

- Real time flow model integration
- Real time BGC model integration

Random Comments –

Current in situ instrumentation is unable to reliably detect microcystis (HAB) even at moderately high concentrations, hindering our ability to understand the relationship between nutrients, residence time, water temperature and HAB blooms.

We are about to embark (~2019) on an ecosystem–scale experiment addressing how changes in nutrients effects aquatic ecosystems. We should take maximum advantage of it.

There is no secure, long-term funding currently identified that supports either (1) the flow/turbidity network, or (2) the nutrient biogeochemistry network. Expires in 2018.

There is frustratingly limited opportunity and funding to support data interpretation and integration across data types and source, and there are limited efforts to harmonize data collection efforts.

THANKS!