Nutrient Sensor Action Challenge

Real time nutrient data to transform decision-making

Informational Webinar

January 30, 2018, 2PM EDT

Webinar Outline

- Welcome and introductions
- Brief recap of previous webinar
- “Best Practices for the Deployment and Use of Nutrient Sensors” with Brian Pellerin, USGS
- Team spotlight: Casco Bay
- Next webinar: Data Management

Projects	Organizers
❑ Casco Bay Estuary Partnership (Maine) ❑ Columbia University (New York) ❑ League of Women Voters (Illinois) ❑ Maryland Association of Soil Conservation Districts (Maryland) ❑ Mystic River Association, USGS (Massachusetts) ❑ Ohio EPA, Great Lakes Environmental Center (Ohio) ❑ Thermo Fisher Scientific, UMASS (Massachusetts) ❑ University of Louisiana at Lafayette (Louisiana) ❑ University of Maryland, MDNR (Maryland) ❑ University of Michigan (Michigan) ❑ University of New Hampshire (New Hampshire)	❑ EPA ❑ NIST ❑ USDA ❑ USGS ❑ NOAA ❑ IOOS

12/19 Webinar Recap

- Overview of Stage II
  - Expectations for sensor deployment
  - Intro to data management
  - Data usage in decision-making
- Stage I team introductions

Best Practices for the Deployment and Use of Nutrient Sensors

Brian Pellerin

USGS, Hydrologic Networks Branch (bpeller@usgs.gov, 703-648-4848)

Nutrient Sensor Action Challenge, Stage II

January 30, 2018

U.S. Department of the Interior
U.S. Geological Survey

Goals of the talk

1. Share some best practices / lessons learned by the USGS during the deployment of sensors*

2. Point towards resources that might be helpful

**List of instruments is not comprehensive, and the use of brand names does not imply endorsement by the USGS.*

Nutrient Sensor Action Challenge

Accelerating affordable nutrient monitoring

- Nutrient pollution is one of America's most widespread, costly and challenging environmental problems, and is caused by excess nitrogen and phosphorus in the air and water.

- This Challenge is a continuation of the Nutrient Sensor Challenge, which helped accelerate the development of next-generation affordable and accurate in situ nutrient sensors. (http://www.act-us.info/nutrients-challenge/)

- Established in response to communities, state and local governments who are interested in taking action to prevent and reduce nitrogen pollution

Market Stimulation

- Coalition of federal agencies, universities, and non-profits bringing incentive prizes and open innovation to the problem of water quality
- **Goal:** Accelerate development and commercial availability of affordable, reliable, and accurate sensors
- Prizes / Challenges:
  - Nutrient Sensor Challenge
  - Arsenic Sensor Challenge
  - Septic System Nitrogen Sensor Challenge
  - Sensors Action Prize
  - Visualizing Nutrients Challenge

USGS

United States Geological Survey

- Government **science** agency (Dept. of Interior, est. 1879)
- USGS serves the nation by providing reliable scientific information to:
  - Describe and understand the earth,
  - Manage water, biological, energy and mineral resources,
  - Enhance and protect our quality of life.
- 8000 employees, $1.2 billion annual budget
- Organized into Mission Areas
  - Climate and Land Use Change
  - Core Science Systems
  - Ecosystems
  - Energy and Minerals
  - Environmental Health
  - Natural Hazards
  - **Water**

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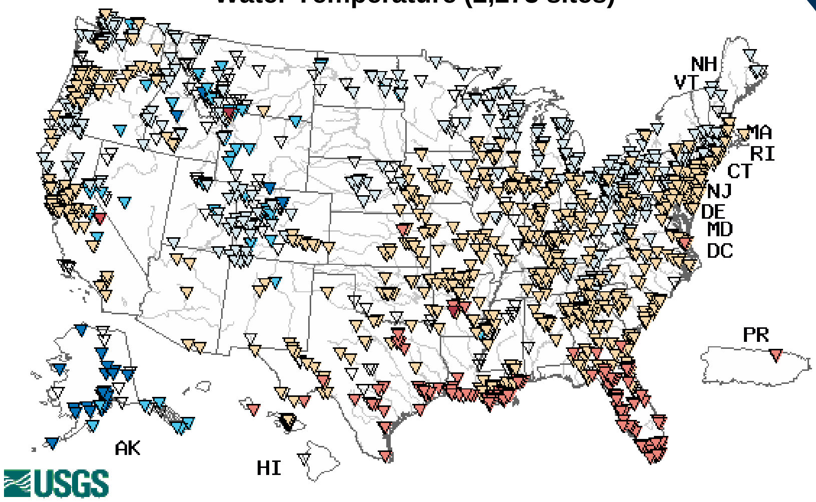
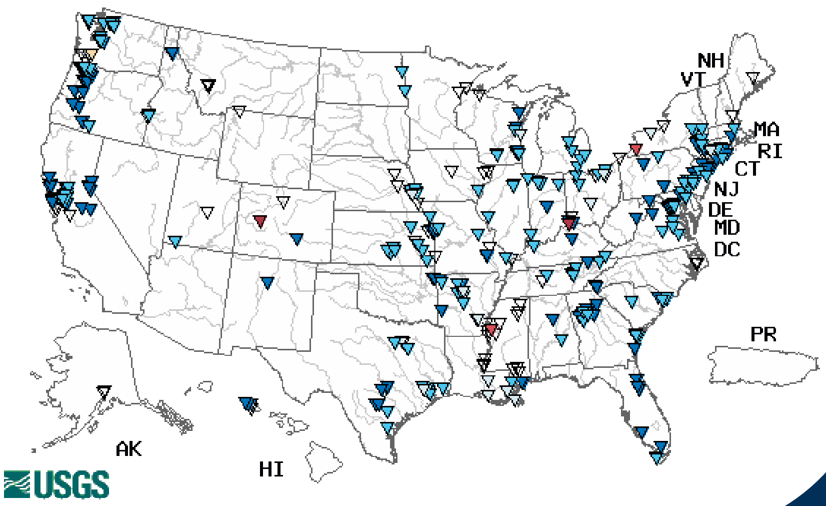
USGS Real-Time Water Quality Data

Parameter	# of Sites
Discharge	8,325
Temperature	2,273
Specific Conductance	1,007
Dissolved Oxygen	569
Turbidity	474
pH	454
Nitrate	130
Chlorophyll fluorescence	55
Orthophosphate	15

Water Temperature (2,273 sites)



Turbidity (474 sites)



Continuous Monitoring

- 24/7 data collection
- Intervals of seconds to hours
- Capture all events
- Real-time transmission
- Wide range of constituents with direct or surrogate measurements
- Remote access and control

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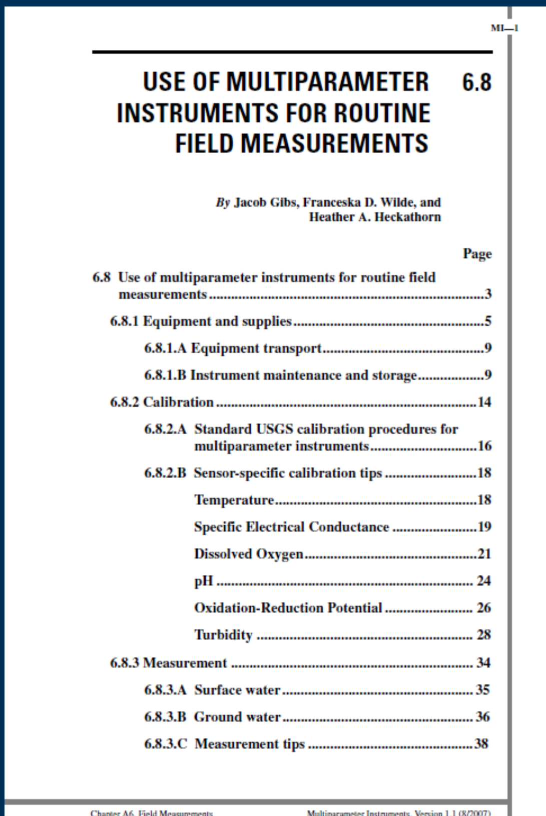
Primary Benefits

1. Real-time data for decision support

2. High temporal frequency of data
   - Observing processes that may otherwise be missed
   - Quantify water-quality status and trends with improved accuracy and lower uncertainty

Guidelines and Protocols

Keys to an accurate, comparable real-time observations on water quality

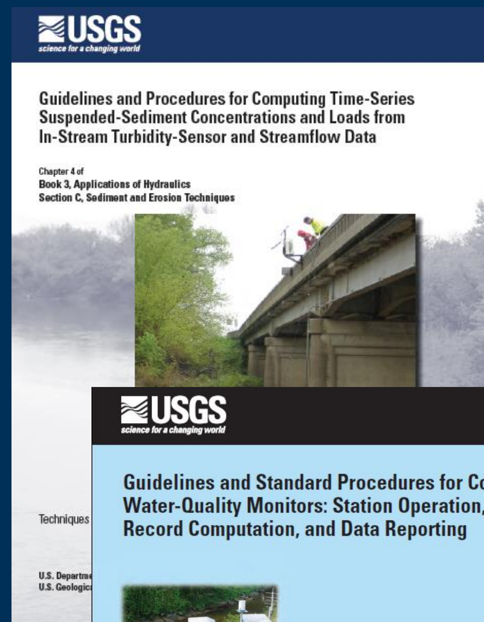


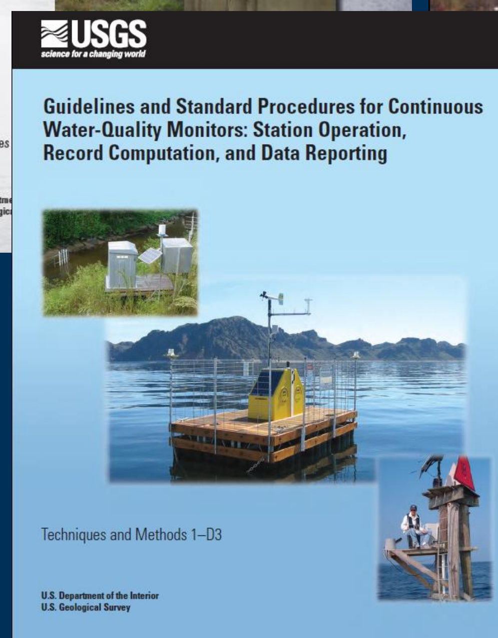
MI—1

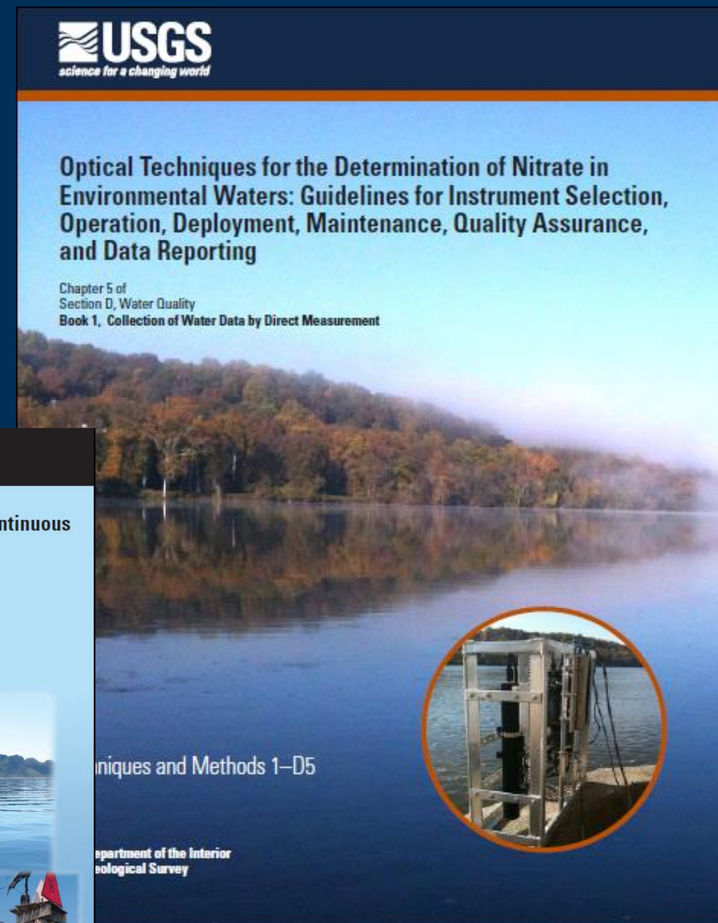
USE OF MULTIPARAMETER INSTRUMENTS FOR ROUTINE FIELD MEASUREMENTS 6.8

By Jacob Gibs, Franceska D. Wilde, and Heather A. Heckathorn

http://water.usgs.gov/owq/FieldManual/







pubs.usgs.gov/tm/01/d5

Instrument Selection

1. **What is the expected range of environmental conditions at the site?**
   - Ranges in concentrations of interfering constituents?
   - Ranges of temperature and maximum depth where the instrument will be deployed?
   - Expected level of biological or mineral fouling?

2. **What are the data specifications concentrations at the site?**
   - Expected range in nitrate concentrations?
   - Accuracy, precision, and detection limit are needed, given the study goals?
   - Optimal sampling interval and measurements per interval to achieve study goals?

3. **What are the site requirements and logistical considerations?**
   - Accessible by land or by boat?
   - Accessible across the range of hydrologic and weather conditions expected for the site (including ice cover)?
   - Does the site have existing infrastructure, power, and communication systems?
   - Anticipated frequency of site visits?
   - Level of technical expertise is available to manage the instruments?

Photos: http://www.mbari.org/twenty/isus.htm; www.hach-lange.co.uk

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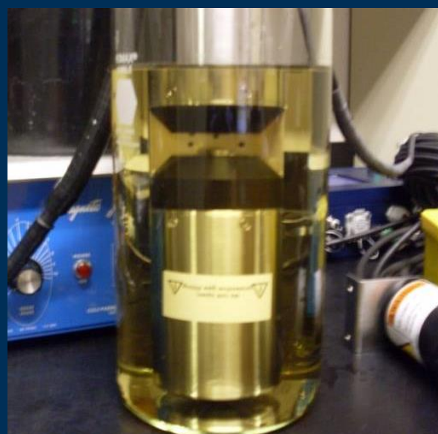
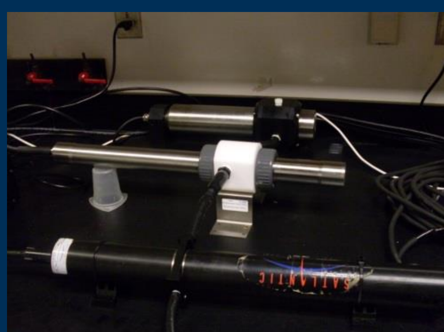
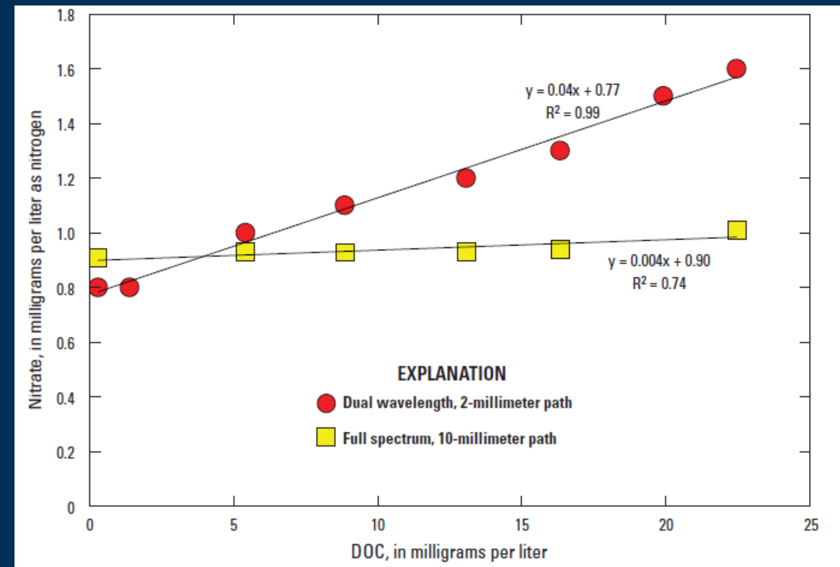
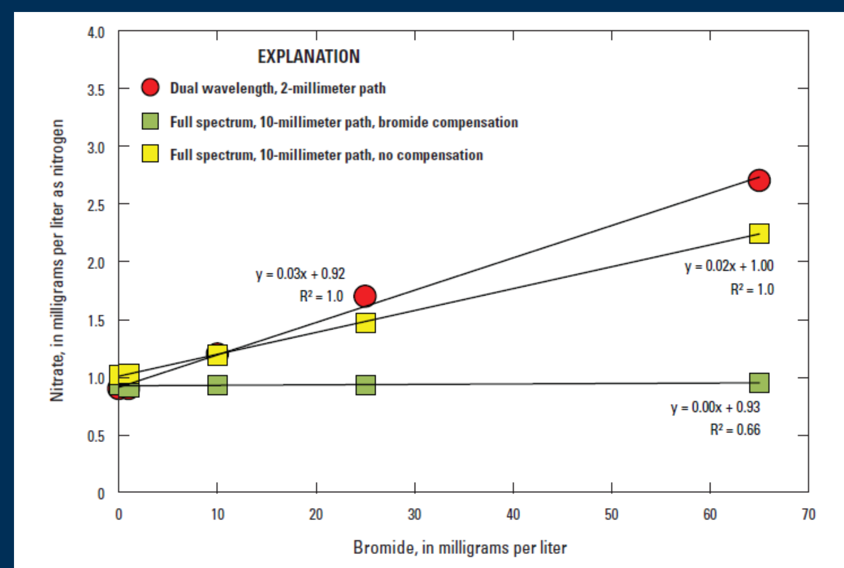
Example of Matrix Interferences

- Response depends on wavelengths, algorithm, path length, etc.









Pellerin et al. 2013, TM1D5.

Considerations for Deployments

- Representativeness
- Access / safety
- Power supply
- Longevity
- Wear-and-tear
- Cost
- Communications
- Vandalism
- Waste collection

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Effective deployments minimize data loss, site visits, and…

Collect data from a location that accurately represents conditions

Allow personnel to safely and easily access the instruments

Keep instruments safe from debris and vandalism

Enable data collection during all flow conditions

Satisfy partner needs

USGS

Source: Jimmy Webber and John Joiner, USGS

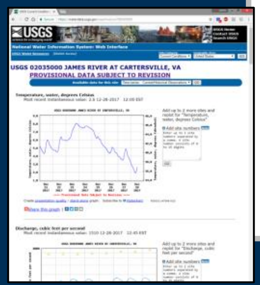
Effective deployments prevent a loss of data by meeting the power, data collection, and data relay requirements of all instruments

POWER
Most instruments are powered using a 30 watt solar panel and a 30-100 amp hr battery

DATA COLLECTION
Most instruments are hardwired into the stream and send measurements to a datalogger

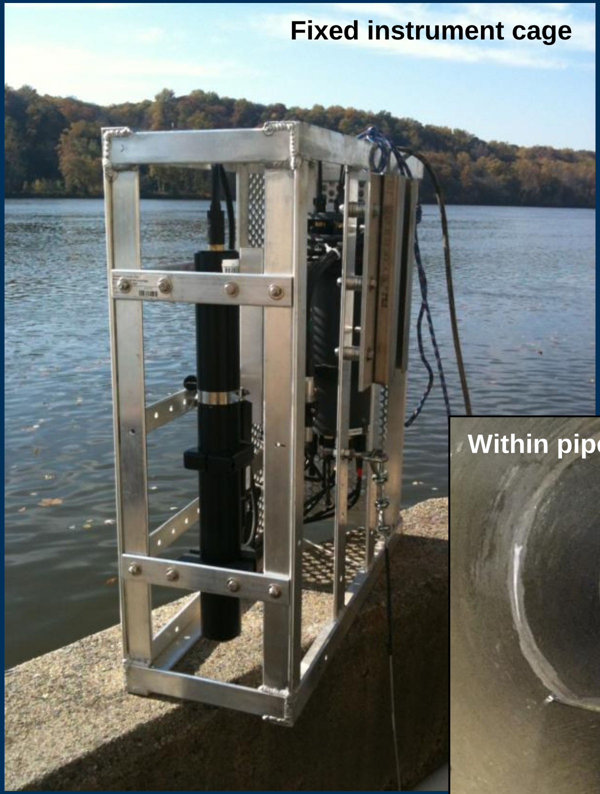
A loss or failure of power, data collection, or data relay results in a potential loss of data

DATA RELAY
Measurements are transmitted to the internet to allow data access in near real-time



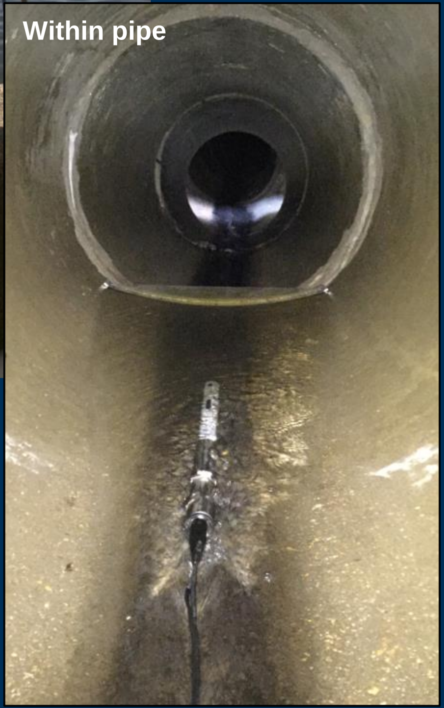
Source: Jimmy Webber and John Joiner, USGS

Deployment Strategies


Fixed instrument cage


Flow-through system

(Photo: Jack Gibs, USGS)


Within pipe

(Photo: Jimmy Webber, USGS)


Buoy deployments

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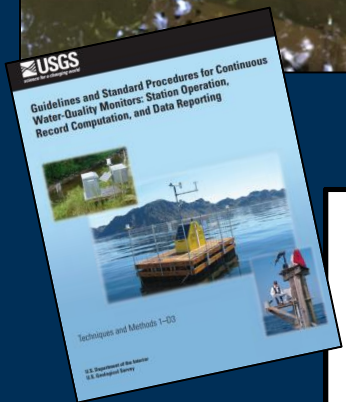
Effective deployments prevent a loss of data by minimizing the frequency and severity of instrument fouling

Deployed instruments can be fouled by sediment, debris, or organic material and need to be cleaned during routine service visits



Guidelines for operating continuous water-quality monitors, including servicing procedures are outlined in Wagner and others, 2006 (TM1-D3)

Service visits also address the calibration drift of deployed instruments through adjustments to known standards

Table 10. Criteria for water-quality data corrections.

[±, plus or minus value shown; °C, degree Celsius; µS/cm, microsiemens per centimeter at 25 °C; mg/L, milligram per liter; pH unit, standard pH unit; turbidity unit is dependent on the type of meter used]

Measured field parameter	Data-correction criteria (apply correction when the sum of the absolute values for fouling and calibration drift error exceeds the value listed)
Temperature (may affect other field parameters)	±0.2 °C
Specific conductance	±5 µS/cm or ±3% of the measured value, whichever is greater
Dissolved oxygen	±0.3 mg/L
pH	±0.2 pH unit
Turbidity	±0.5 turbidity units or ±5% of the measured value, whichever is greater

Fouling or calibration drift that exceeds established criteria require measured data to be deleted

Source: Jimmy Webber and John Joiner, USGS

Anti-fouling

- Many way to prevent biofouling / deposition:
  - Filtering
  - Copper guards
  - Wipers
    - Brushes
    - Silicon blades
  - Air blasts
  - Mounting position

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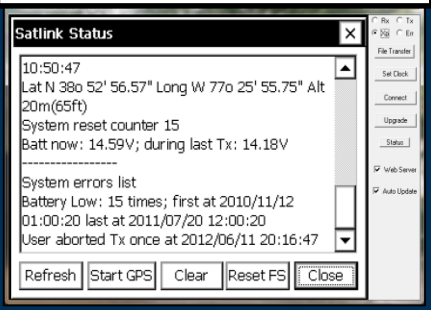
Utility of Two-Way Remote Communication

Remote two-way communication with datalogger programs can be used to prevent or better inform site visits

The utility of remote access can be customized based on site and project specific needs and include the ability to…

Stop measuring samples during conditions that will cause the instrument to foul

View diagnostic information about data measurement or transmission problems



Access site cameras to visually inspect stream conditions

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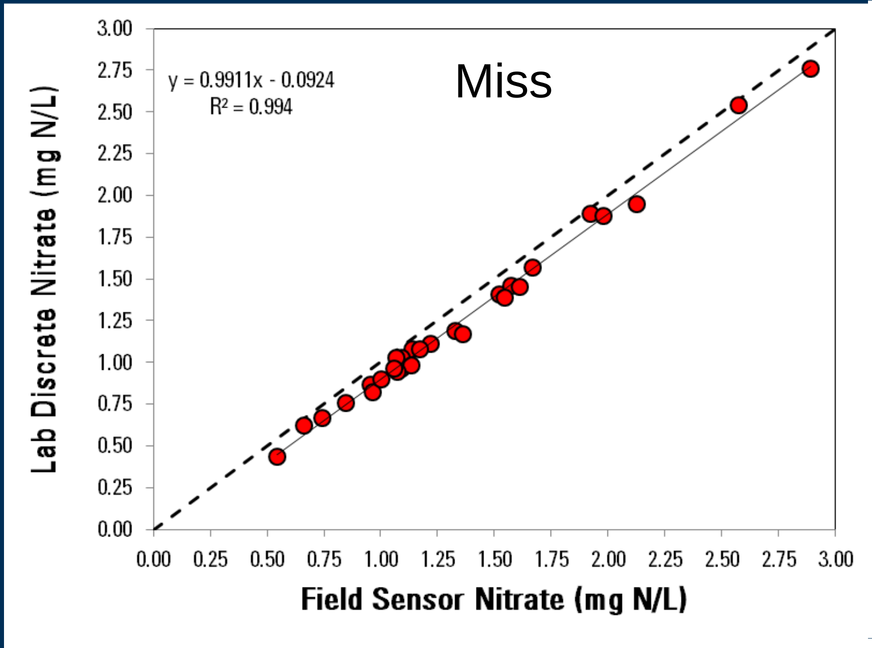
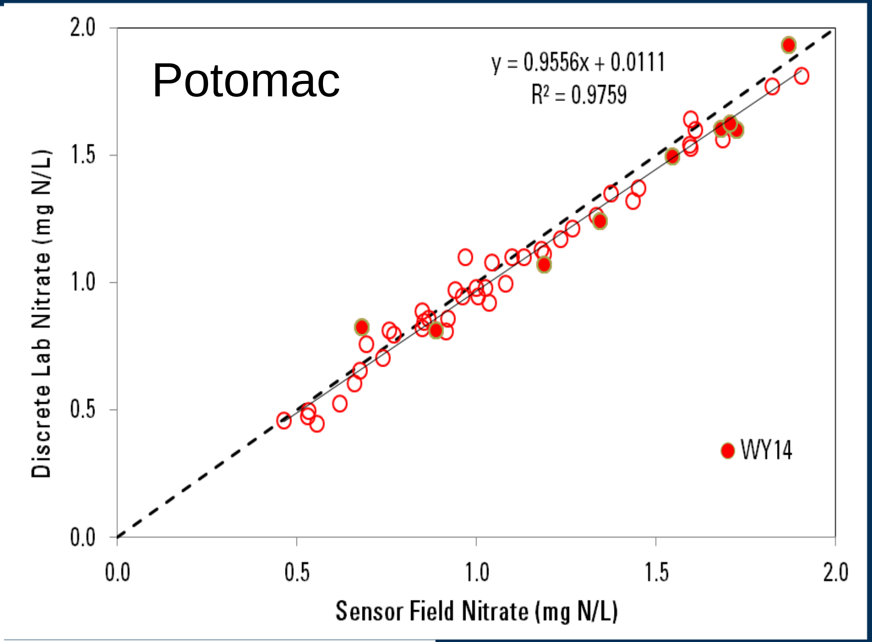
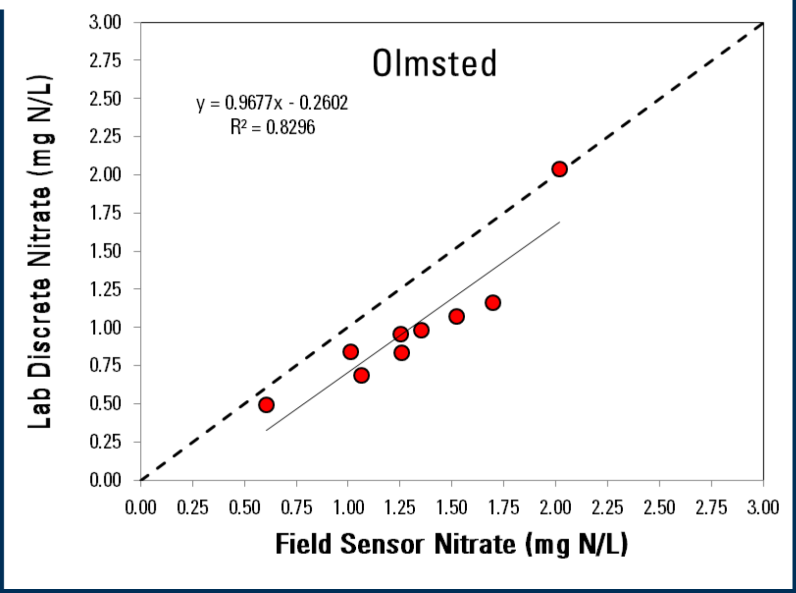
Source: Jimmy Webber and John Joiner, USGS

Comparison to Discrete Samples







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Sensor Metadata

- **Sensor-specific**
  - Sensor type
  - Serial number(s)
  - Days since last service
  - Lamp hours
  - Number of wipes
  - Internal temperature / voltage / humidity
  - …
- **Data-specific**
  - Missing values
  - Fitting parameter
  - Light counts
  - Burst statistics
  - Trends in the data
  - …

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Benefits for Sensor and Data Users

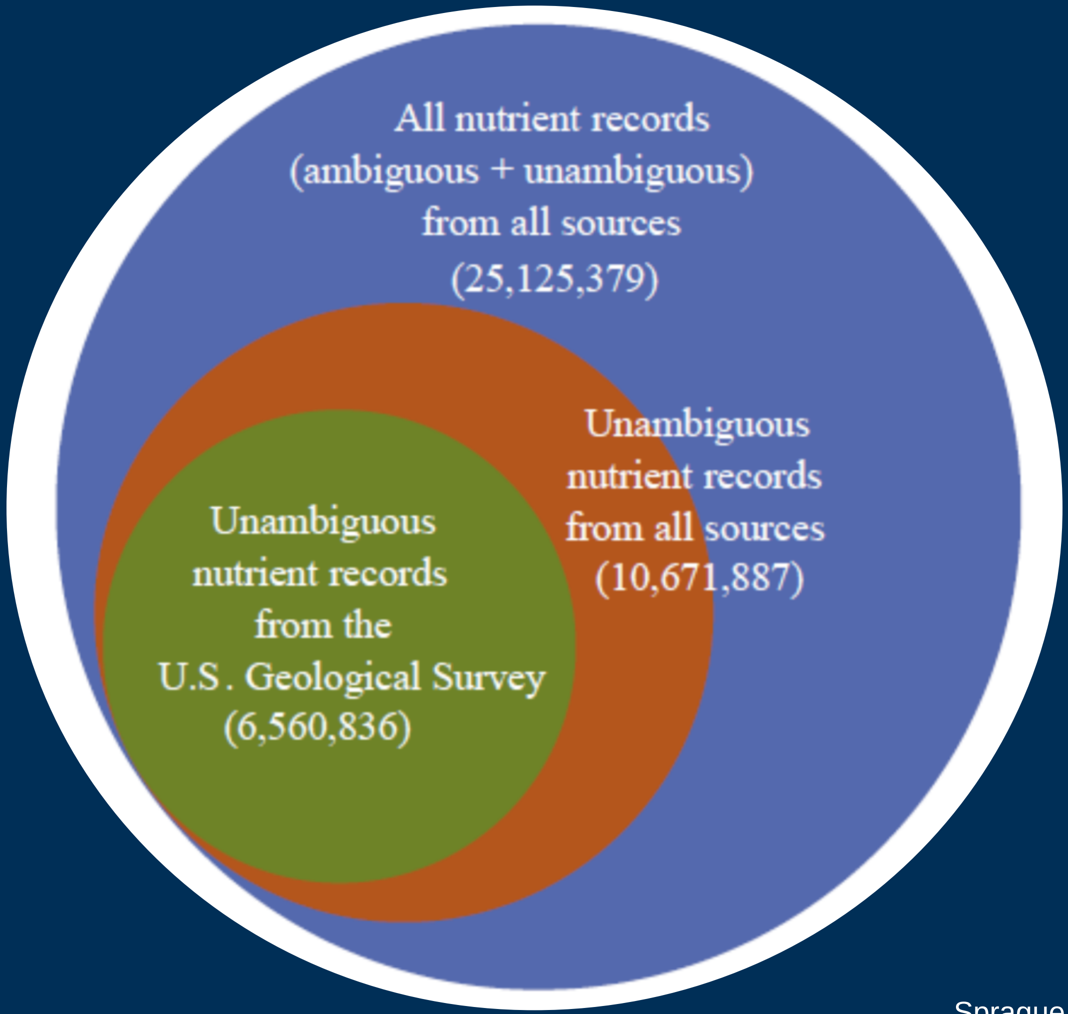
1. Improvements in efficiency (sensor operation and data management)
2. Consistency in data quality
3. Interoperability across users and sites

QARTOD
QUALITY ASSURANCE OF REAL-TIME OCEANOGRAPHIC DATA

Table 3-1. Flags for real-time data (UNESCO 2013)

Flag	Description
Pass=1	Data have passed critical real-time quality control tests and are deemed adequate for use as preliminary data.
Not Evaluated=2	Data have not been QC-tested, or the information on quality is not available.
Suspect or Of High Interest=3	Data are considered to be either suspect or of high interest to data providers and users. They are flagged suspect to draw further attention to them by operators.
Fail=4	Data are considered to have failed one or more critical real-time QC checks. If they are disseminated at all, it should be readily apparent that they are not of acceptable quality.
Missing Data=9	Data are missing; used as a placeholder.

Cost of Ambiguous Metadata



Ambiguous nutrient data are a valuable resource worth billions of dollars to secondary users

- parameter name
- units
- chemical form
- sample fraction
- data quality / BDL codes
- …

Sprague et al., 2017, Challenges with **secondary use** of multi-source water-quality data in the United States. Water Research, 110, http://dx.doi.org/10.1016/j.waters/2016/12/024

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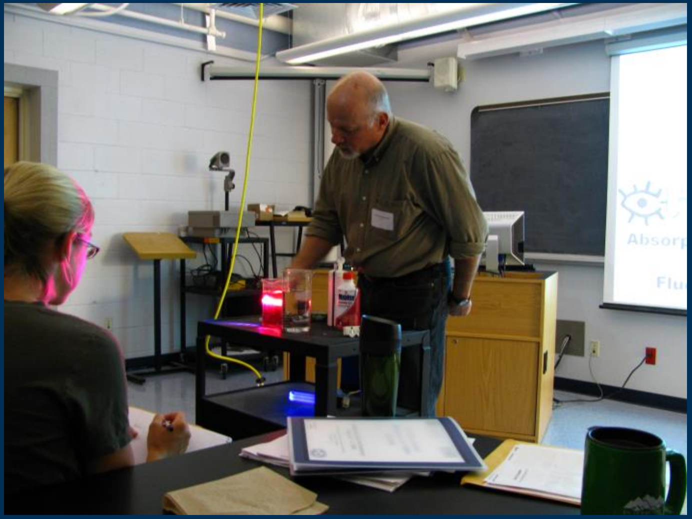
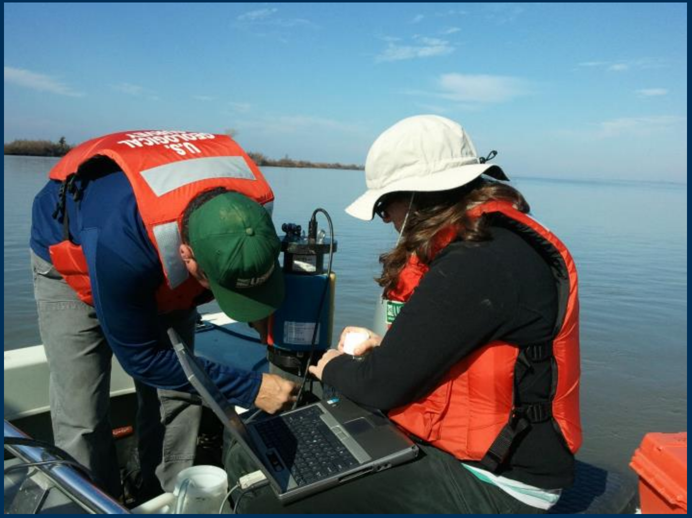
Useful References

- **Instrument user manuals**
- **USGS Techniques and Methods Reports**
  - TM1D3 – Continuous Monitoring
  - TM1D5 – Optical Nitrate Sensors
- **USGS National Field Manual**
- **Quality Assurance of Real-Time Oceanographic Data (QARTAD)**

Other Considerations

- Ancillary data
- Cross validation
  - Side-by-side field samples
  - Laboratory samples
- Laboratory evaluation
- Document methods
- Training





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Questions?

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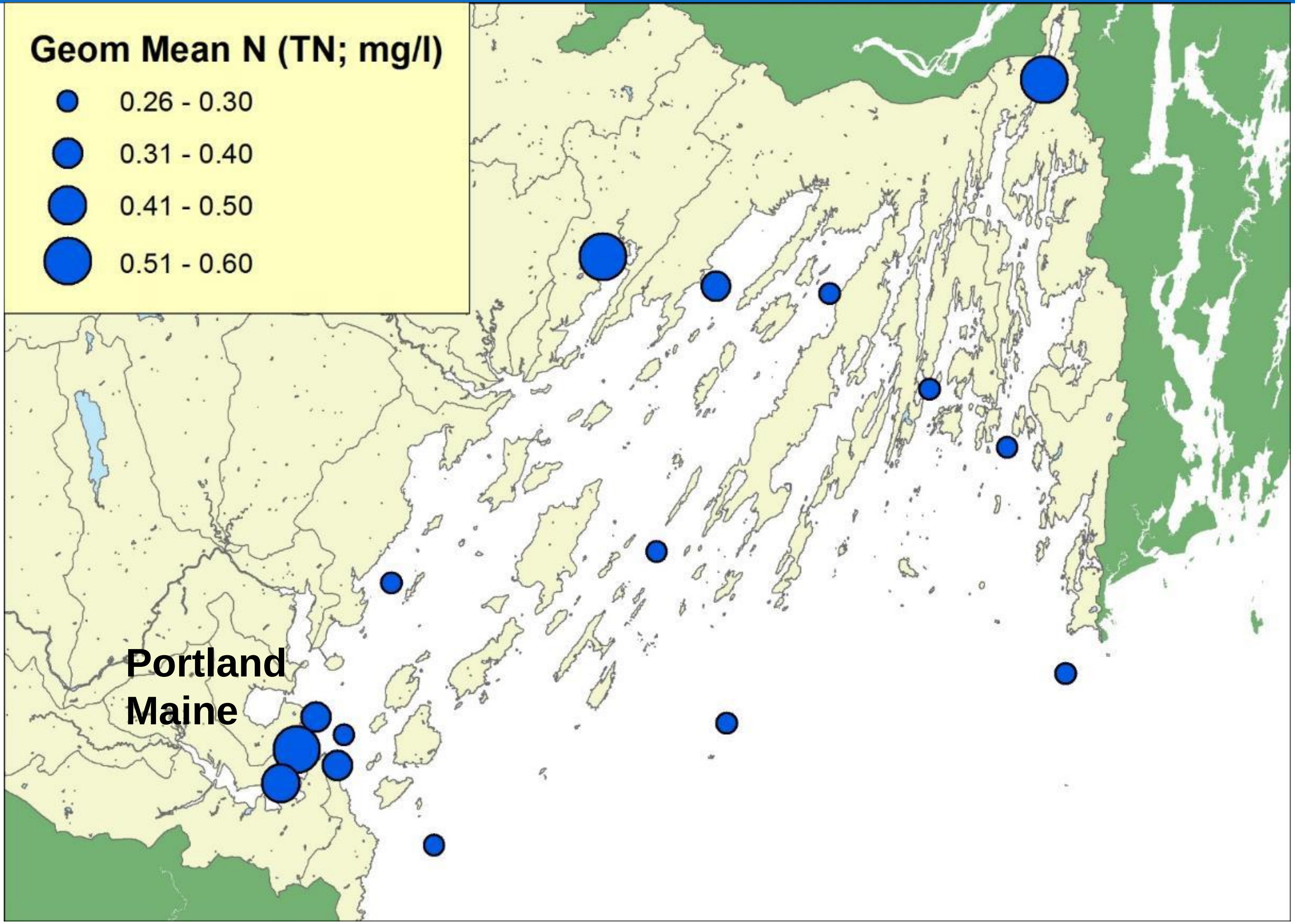
CASCO BAY NITROGEN SENSOR DEPLOYMENT 2018

Curtis C. Bohlen

Director, Casco Bay Estuary Partnership

Nitrogen in Casco Bay



Data:
FOCB
Ca. 2014

Major Costs to Communities

- East End WWTP Upgrade
  - ~ $40 million
- Long Creek Watershed Management District
  - $14 million
    - just in the first decade.
    - ~ 2.3 square miles
- Portland's CSO Plan
  - $170 million

Casco Bay Nutrient Council

- Seek cost-effective solutions to nutrient pollution of Casco Bay
- Membership includes:
  - Wastewater Treatment Facilities
  - Municipal staff
  - Environmental advocates
  - Academics
  - Engineers and scientists
- Council is intentionally NOT political
- Professionally facilitated

Relicensing, 2016-2017

East End WWTP

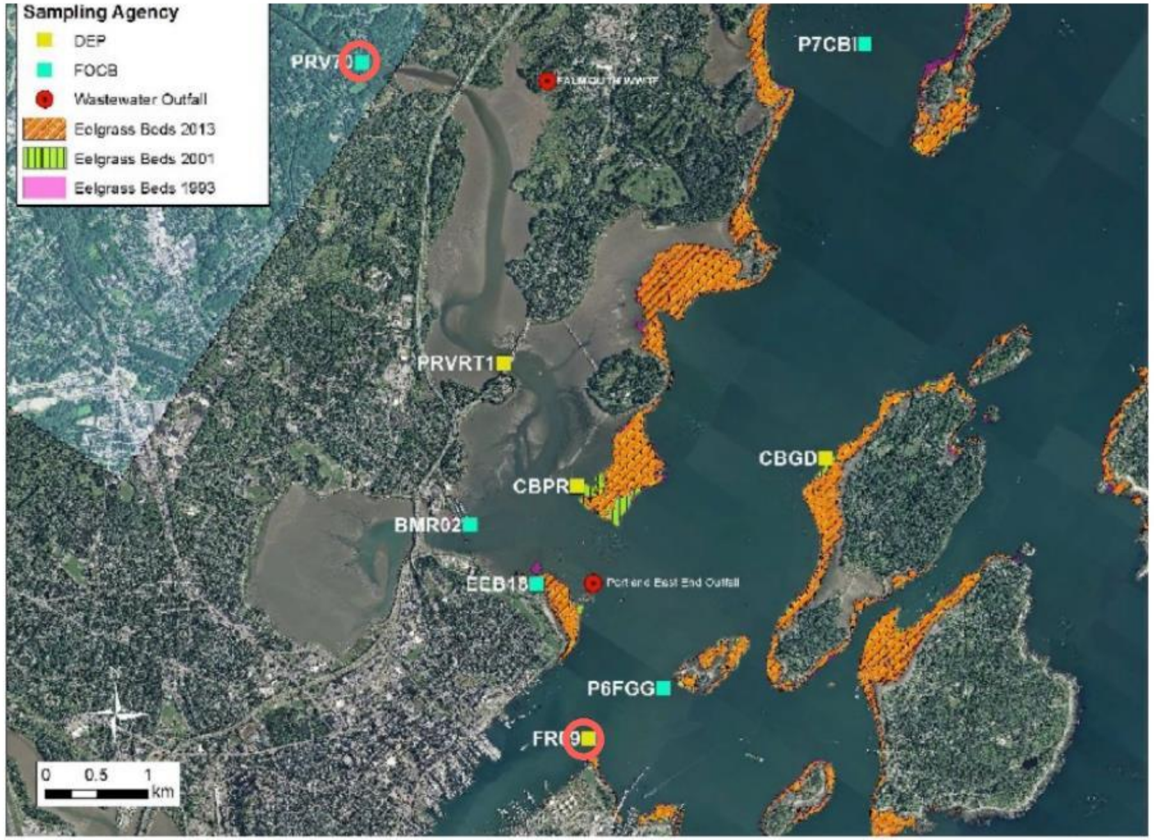
- Key Players:
  - Portland Water District
  - Maine Department of Environmental Protection
  - Friends of Casco Bay
- Upgrade to technology based standards would cost ~ $40 million
- Agreement:
  - Take immediate steps to reduce N loads via operational changes, learn what can be accomplished
  - Work together to understand nutrient sources and impacts surrounding the Plant

Partners

- Casco Bay Estuary Partnership
- Friends of Casco Bay
- Maine Department of Environmental Protection
- Portland Water District
- University of Maine
- University of Southern Maine
- National Oceanography Center

Baxter Boulevard CSO Conduit
Under Construction

2017 Monitoring Program



- Led by FOCB and DEP
- Nutrients
  - Grab samples (NO_x, NH_4, TN), nine locations
- Continuous WQ data:
  - Two plus Two locations
- Eelgrass:
  - One dive on each of two beds

Using Nitrogen Sensors in 2018

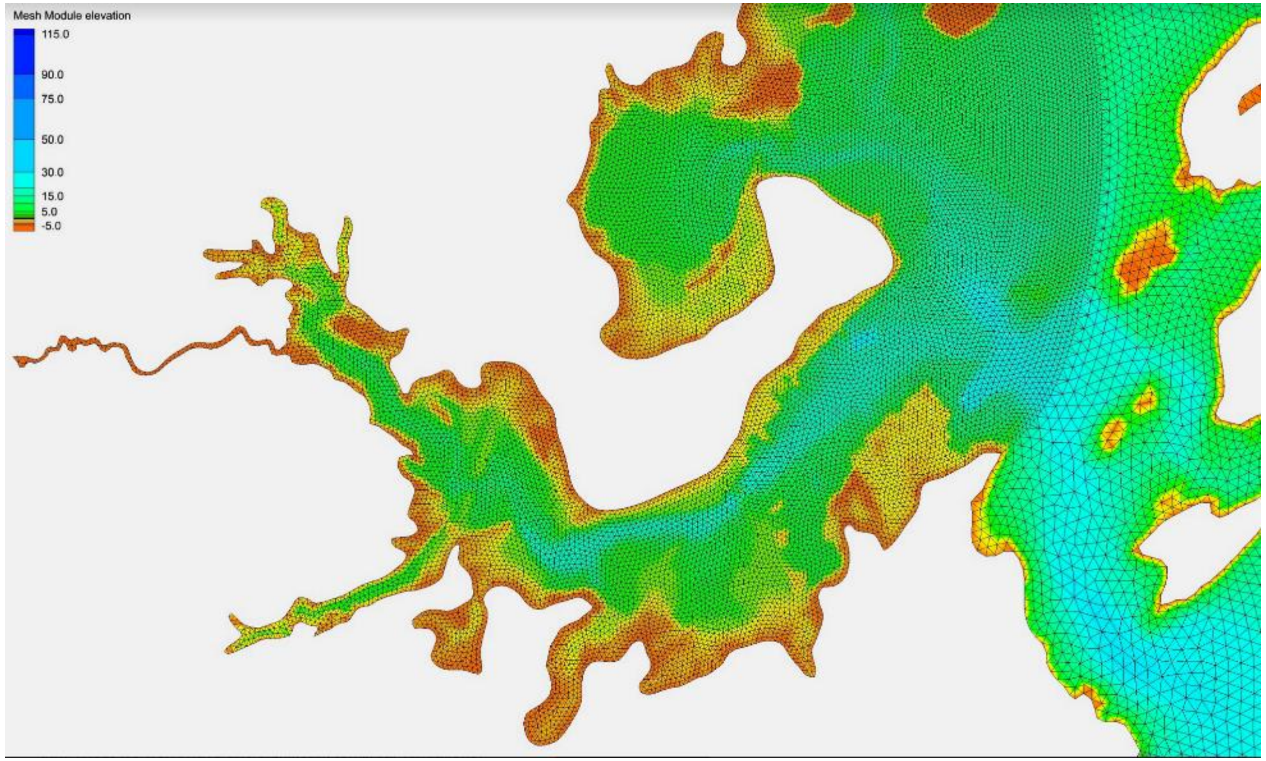
- Continue grab samples
- Continuous data
  - At least two locations
  - Multiple Sensors technologies?
  - Focus on nitrate/nitrite
    - NOC Lab-on-Chip Nitrate Sensor
    - The Systea WIZ probes
  - Three week deployments
    - Biofouling
    - Frequent comparison to grab samples and SUNA
- Careful data QA/QC comparing sensors and grab samples
- Surface NO_x and NH_4 mapping using boat-mounted SUNA and ammonia analyzers coupled to GPS

Emerging Challenges

- Deployment logistics
  - Batteries
  - Security
  - Access
- Managing multiple data streams
  - Tides
  - Precipitation
  - River discharge
  - CSO discharges
  - WWTF discharges

Future

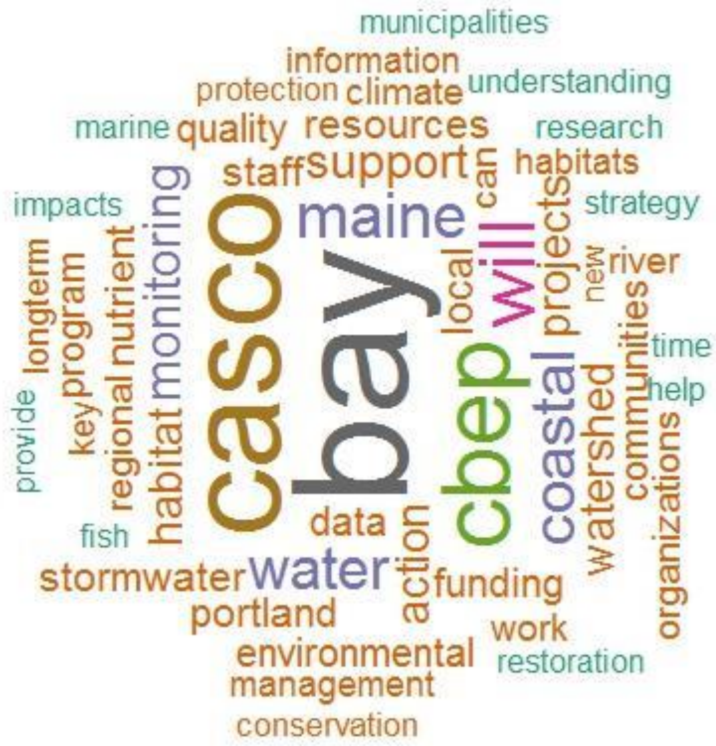
- Integration with hydrodynamic models?



UMaine researchers have developed a high resolution hydrodynamic model of the region

Thank You

Long Reach Lane Culvert Replacement



Casco Bay Plan Word Cloud

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Next Webinar – Data Management

- Tuesday, February 6, 2-3pm EDT
- Registration link in 1/23 e-newsletter
- Topics
  - Data management overview
  - Sensor technology
  - Data acquisition and communication
  - Storage considerations
  - Platform/enablement
  - Data access

Questions?

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www.challenge.gov/nutrient-sensor-action-challenge

#NutrientSensorAction