Real-Time NO_3 and PO_4 Sensors for Chesapeake Bay

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Innovation

Nutrient Sensor Action Challenge

The Nutrient Sensor Action Challenge is a technology-accelerating water quality challenge to demonstrate how nutrient sensors can be used by states and local communities to help manage nutrient pollution. Find out more about nutrient pollution here.

The Challenge calls for demonstrations showing:

- The effective use of low-cost sensors
- Innovative partnerships to pilot the sensors
- How collected data and information can be part of state and local decision-making.

Stage I

In Stage I of the Nutrient Sensor Action Challenge, which closed September 20, 2017, teams submitted action plans detailing how they intend to deploy and use sensors to meet Challenge goals.

- Read the **press release** for the launch of the challenge here.
- Read more about Stage I of the Challenge here on the **Challenge.gov post**.
- Learn more about the **five winning proposals** from Stage I here.

Why do we need these sensors?

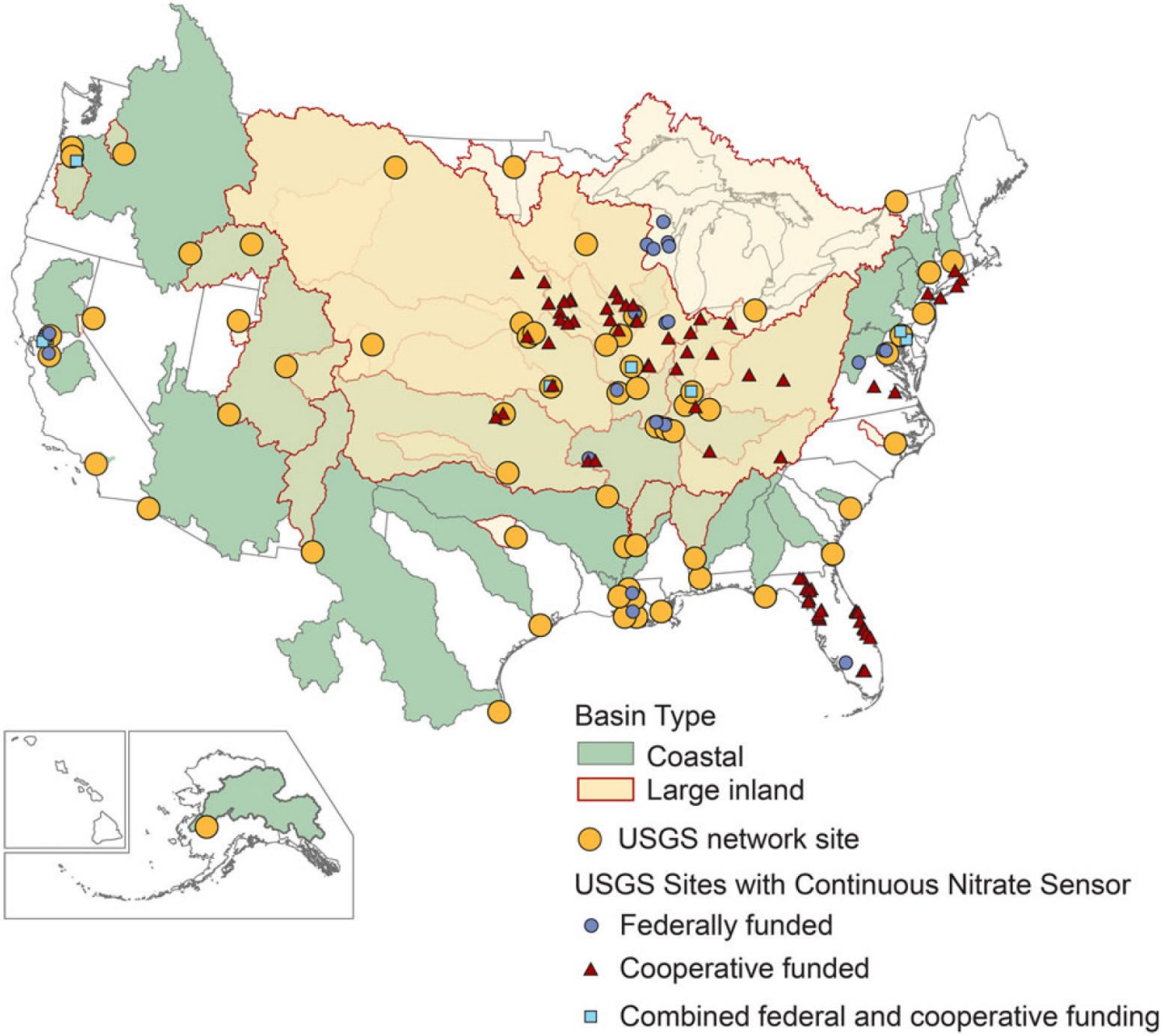
(1) There is a vast amount of nutrient concentration measurements in Chesapeake Bay, but most of these have been measured at a bi-weekly or monthly scales

(2) Event-scale dynamics (floods, wind events) are poorly understood

(3) Nutrient conditions leading to phytoplankton blooms poorly understood

(4) Model simulations made at short time scales that could be better validated

Growing use of in-situ nutrient systems



Pellerin et al. 2016, JAWRA

Contents lists available at ScienceDirect

Harmful Algae

journal homepage: www.elsevier.com/locate/hal

In situ nutrient monitoring: A tool for capturing nutrient variability and the antecedent conditions that support algal blooms

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[a] University of Maryland Center for Environmental Science, Horn Point Laboratory, PO Box 775, Cambridge, MD 21613, USA
[b] Maryland Department of Natural Resources, Tidewater Ecosystem Assessment Division, 580 Taylor Avenue, D2, Annapolis, MD 21401, USA

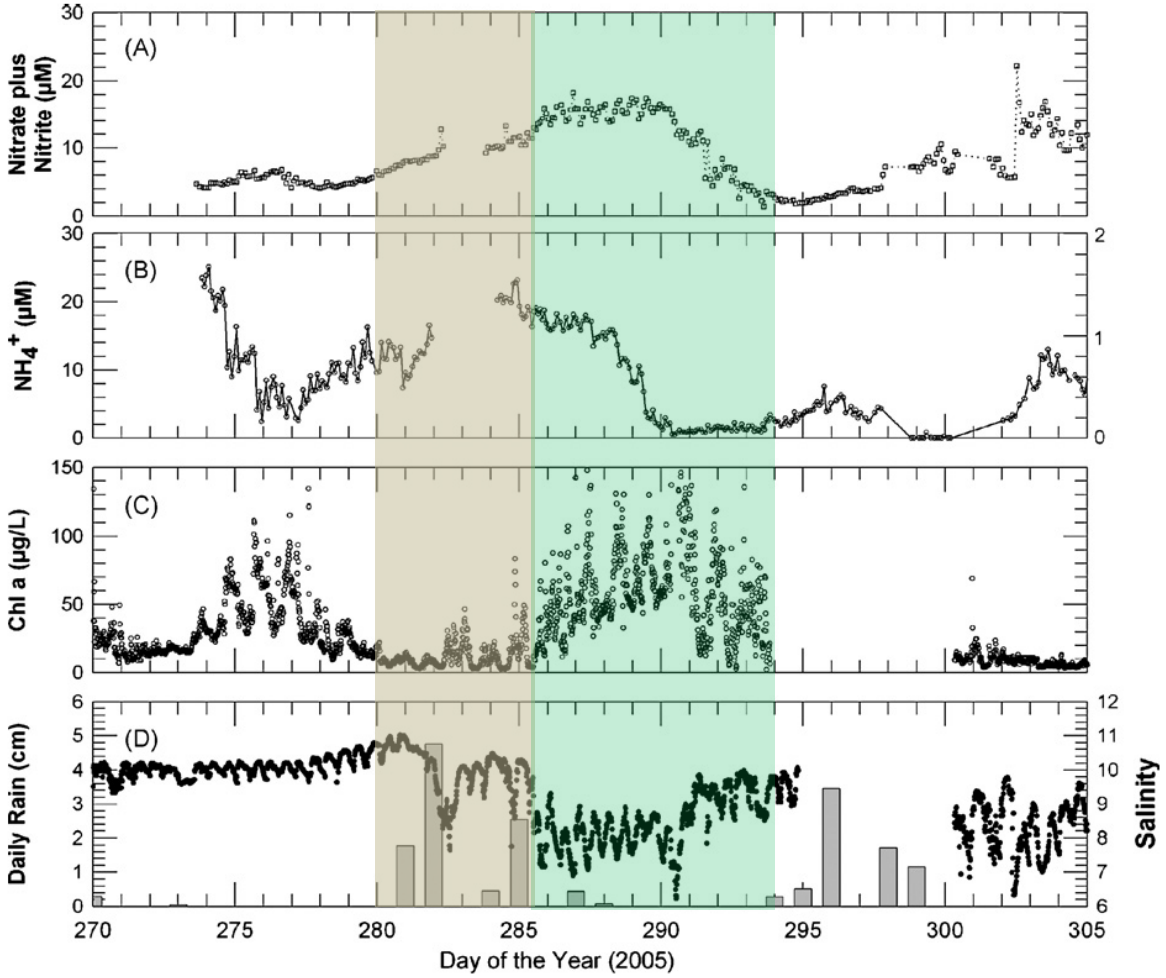
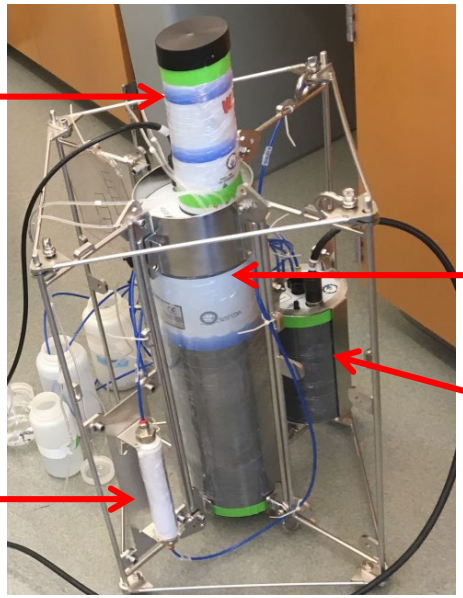


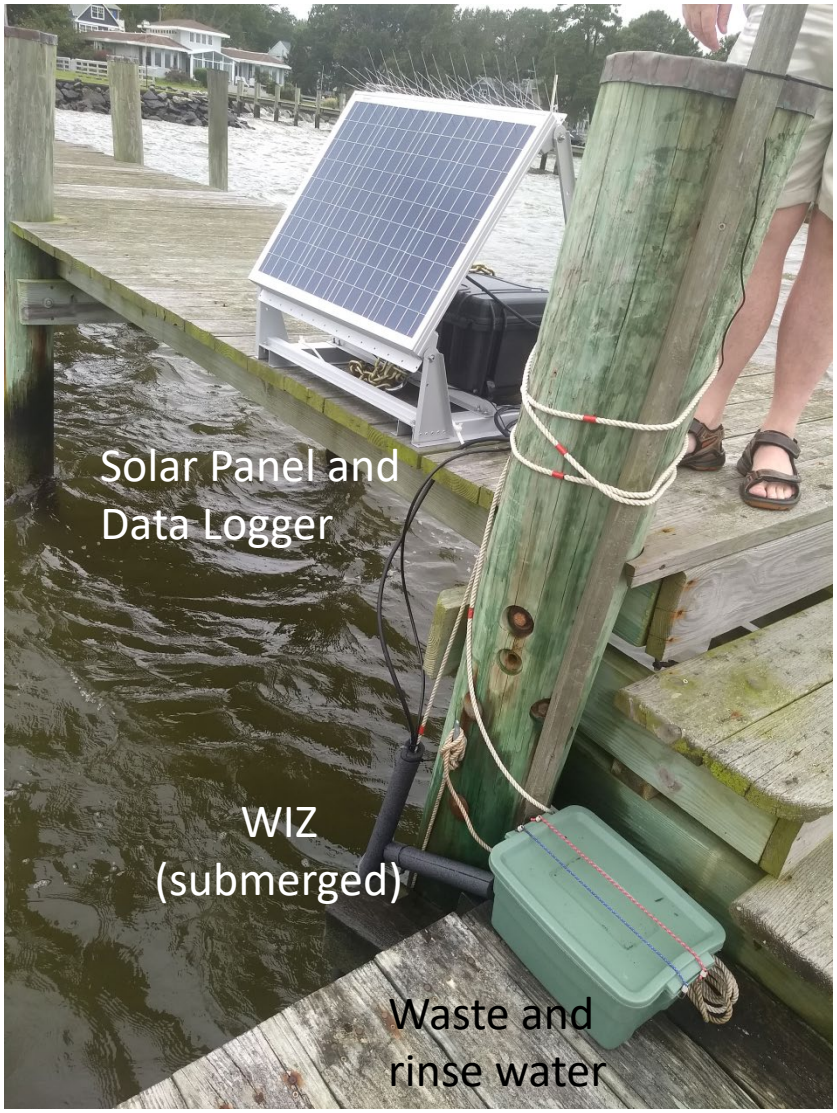
Fig. 3. Time series of nitrate plus nitrate ($NO_3^- + NO_2^-$; panel A), ammonium (panel B), chlorophyll *a* (panel C) and rainfall (panel D, gray bars) and salinity (panel D, line) for the Corsica River for Julian Days 270–305, 2005.

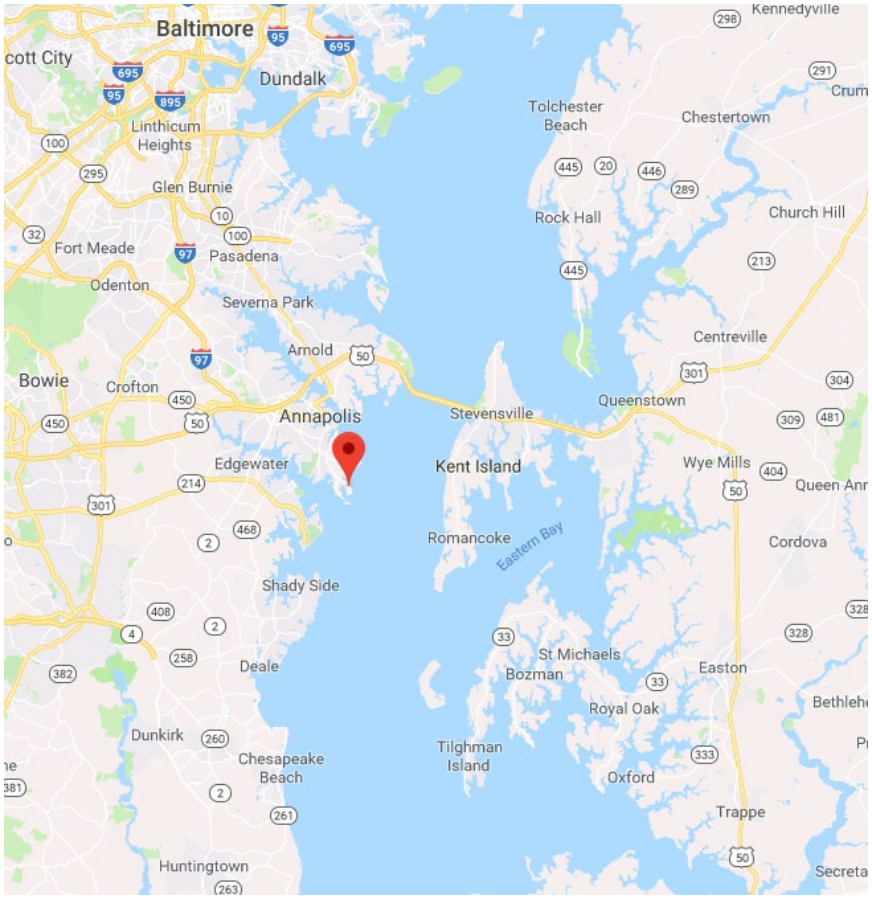
The WIZ system

- Miniaturized wet chemistry
- Won EPA Nutrient Sensor Challenge
- Relatively affordable
  (10-15k; SUNA=30k+)



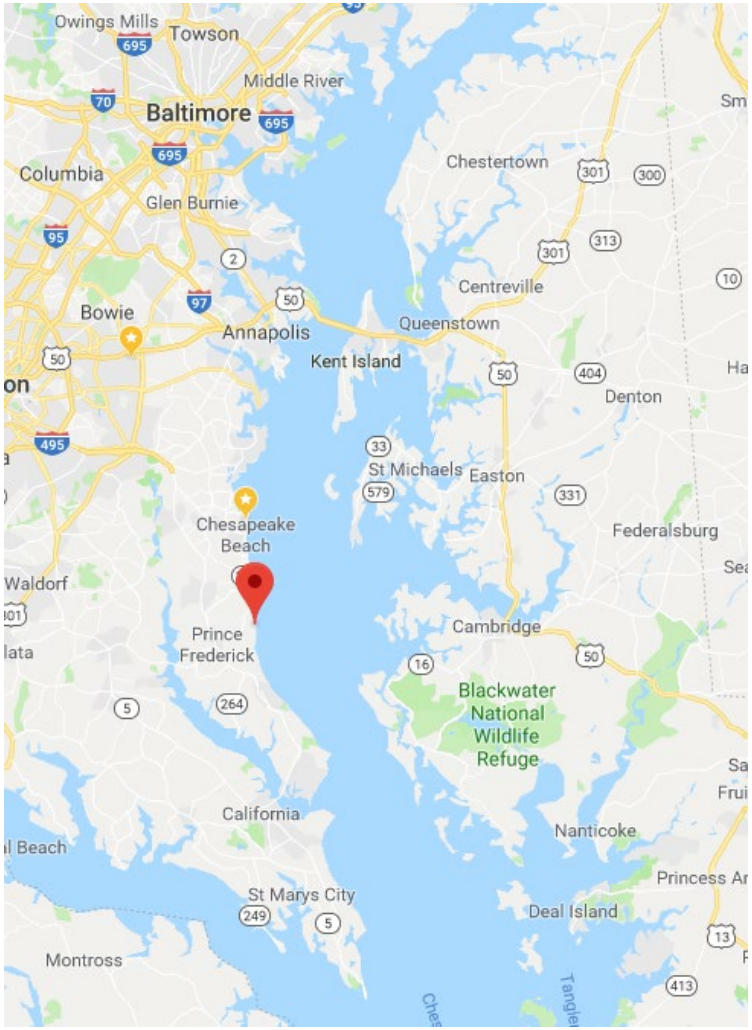
Deploying The WIZ system





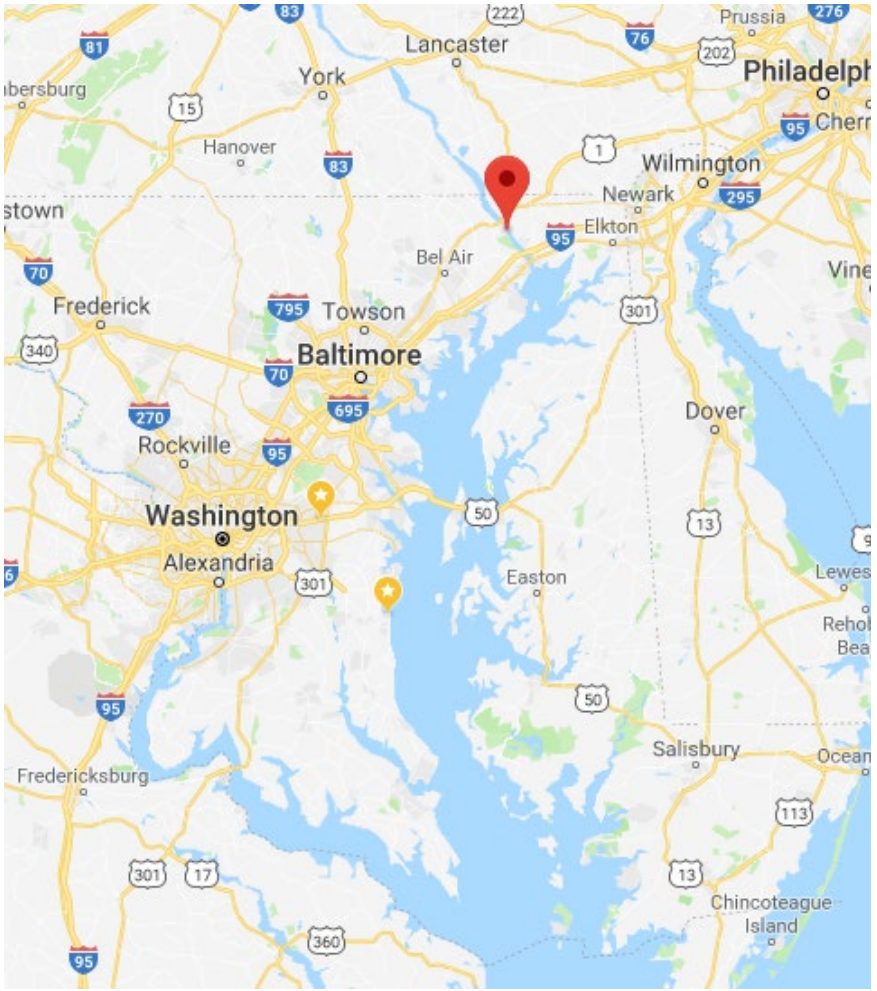
Arundel on the Bay

Deploying The WIZ system



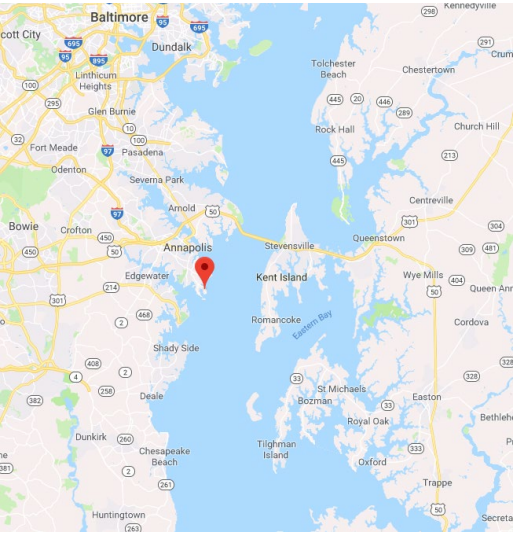
Dares Beach

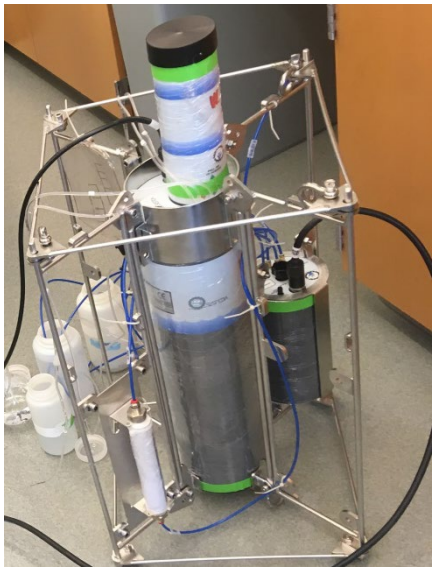
Existing Nitrate Sensor

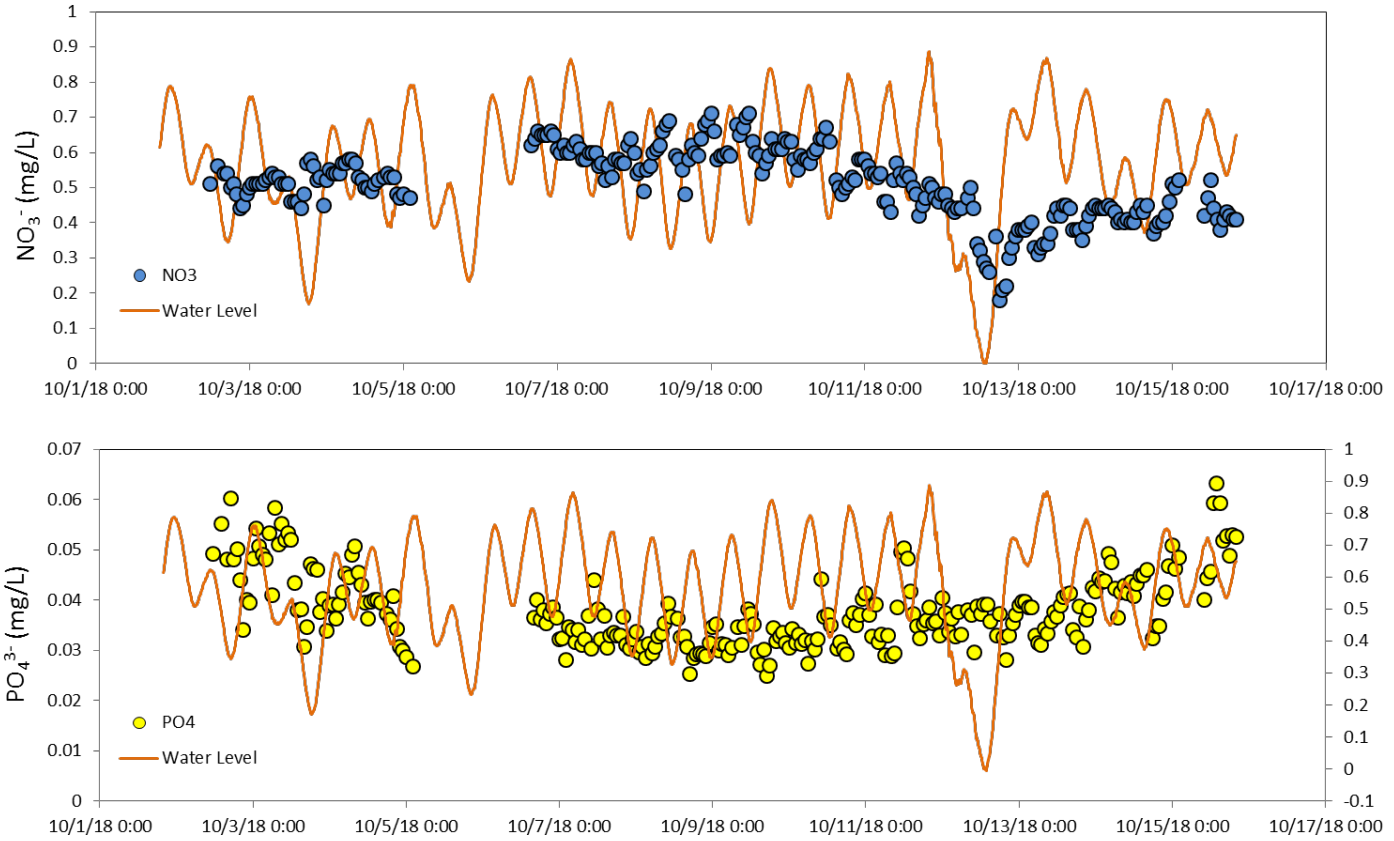


Darlington, MD

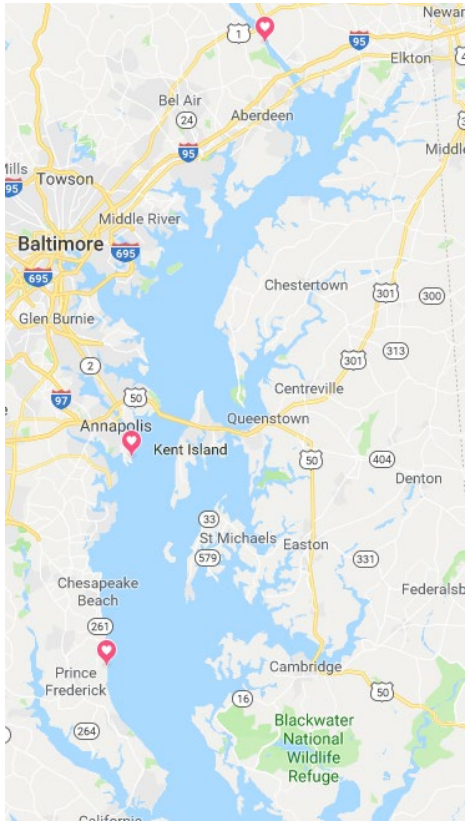
Water In site AnalyZer System (WIZ):
Real-Time NO3 and PO4 measurements

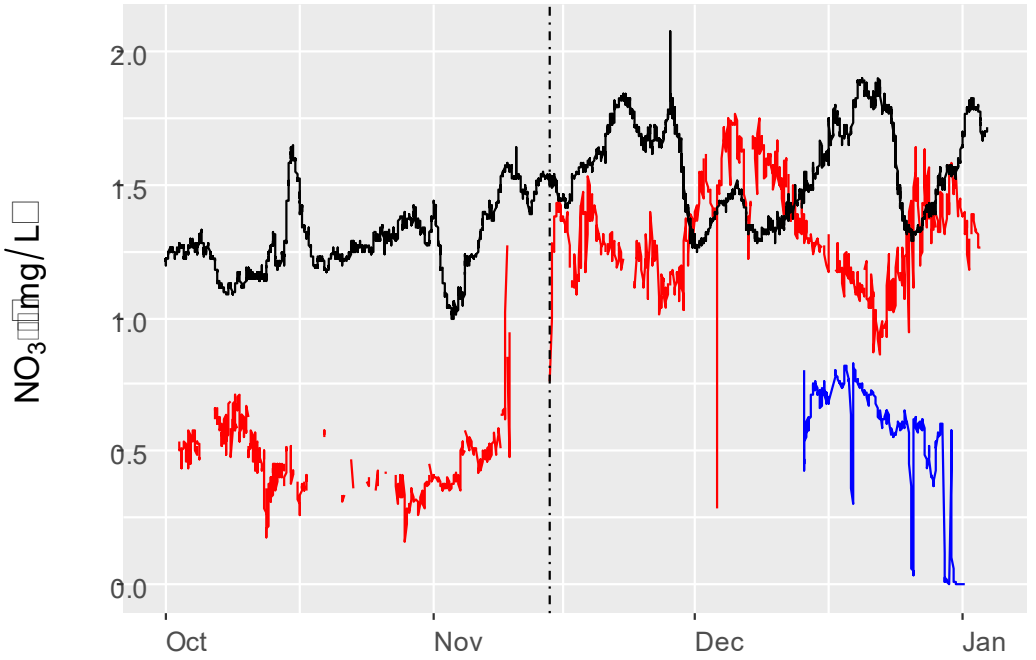


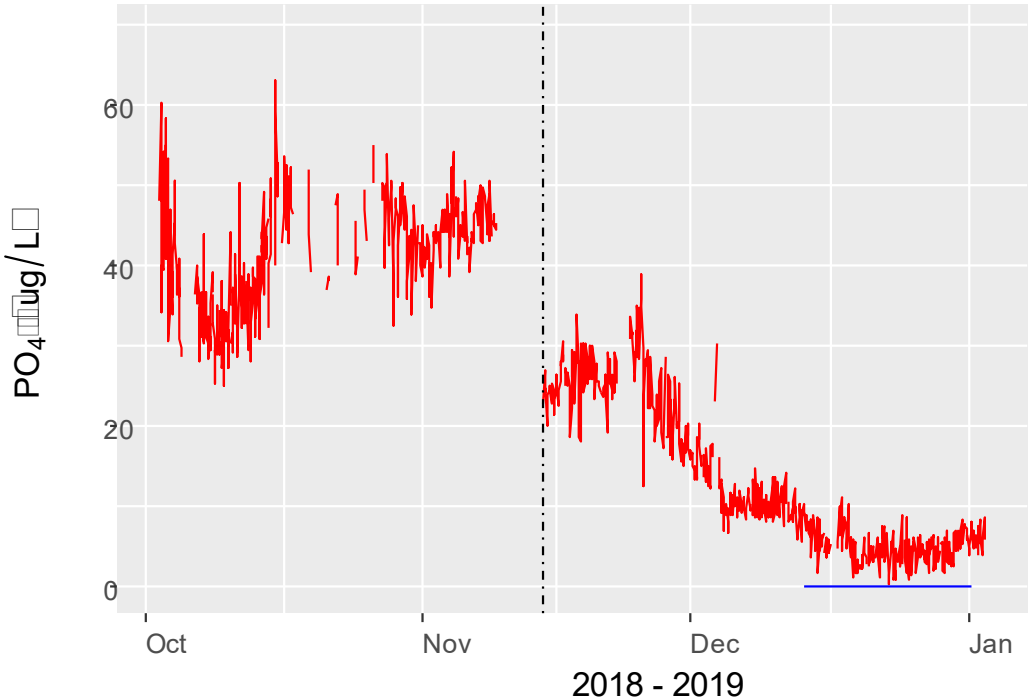


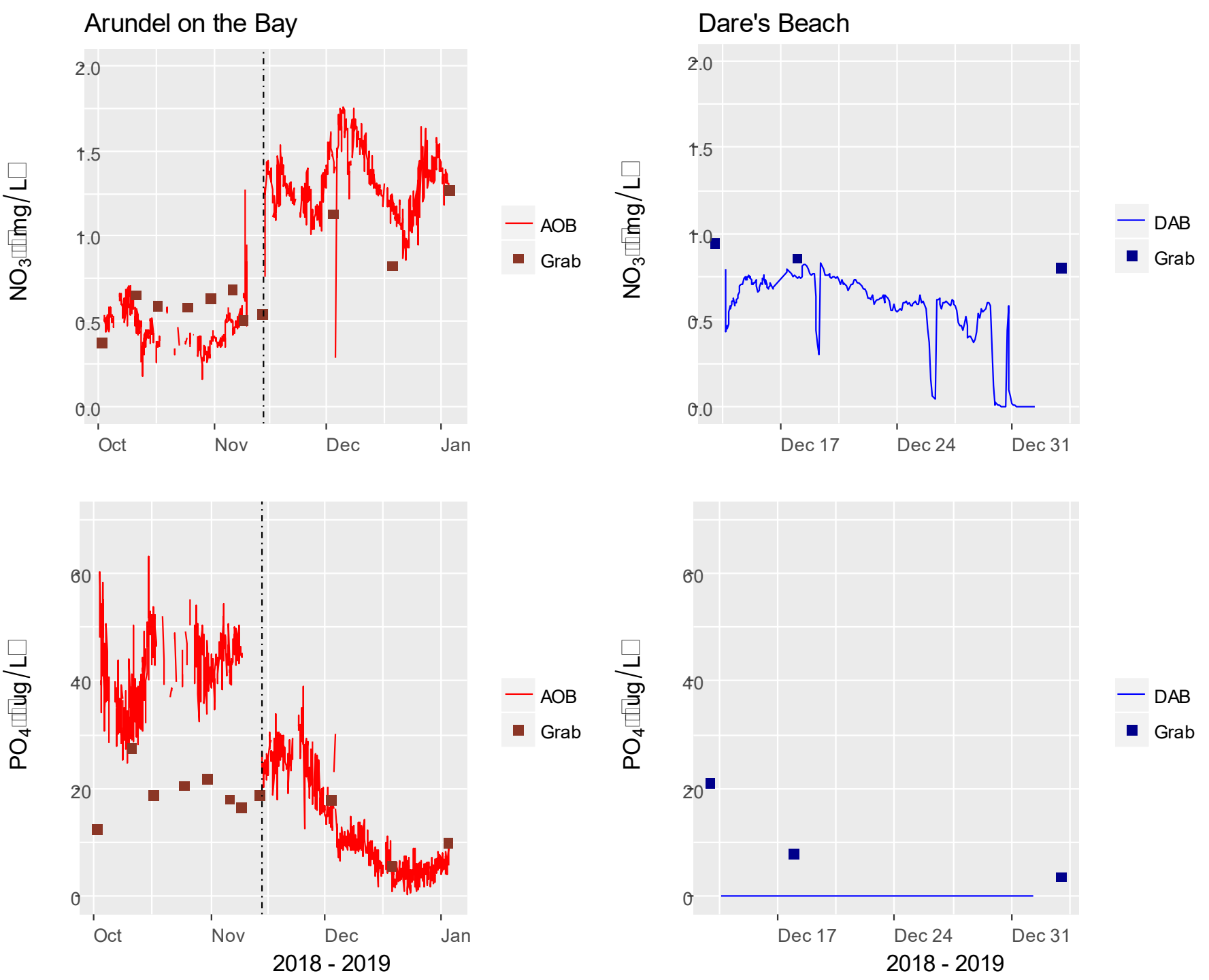


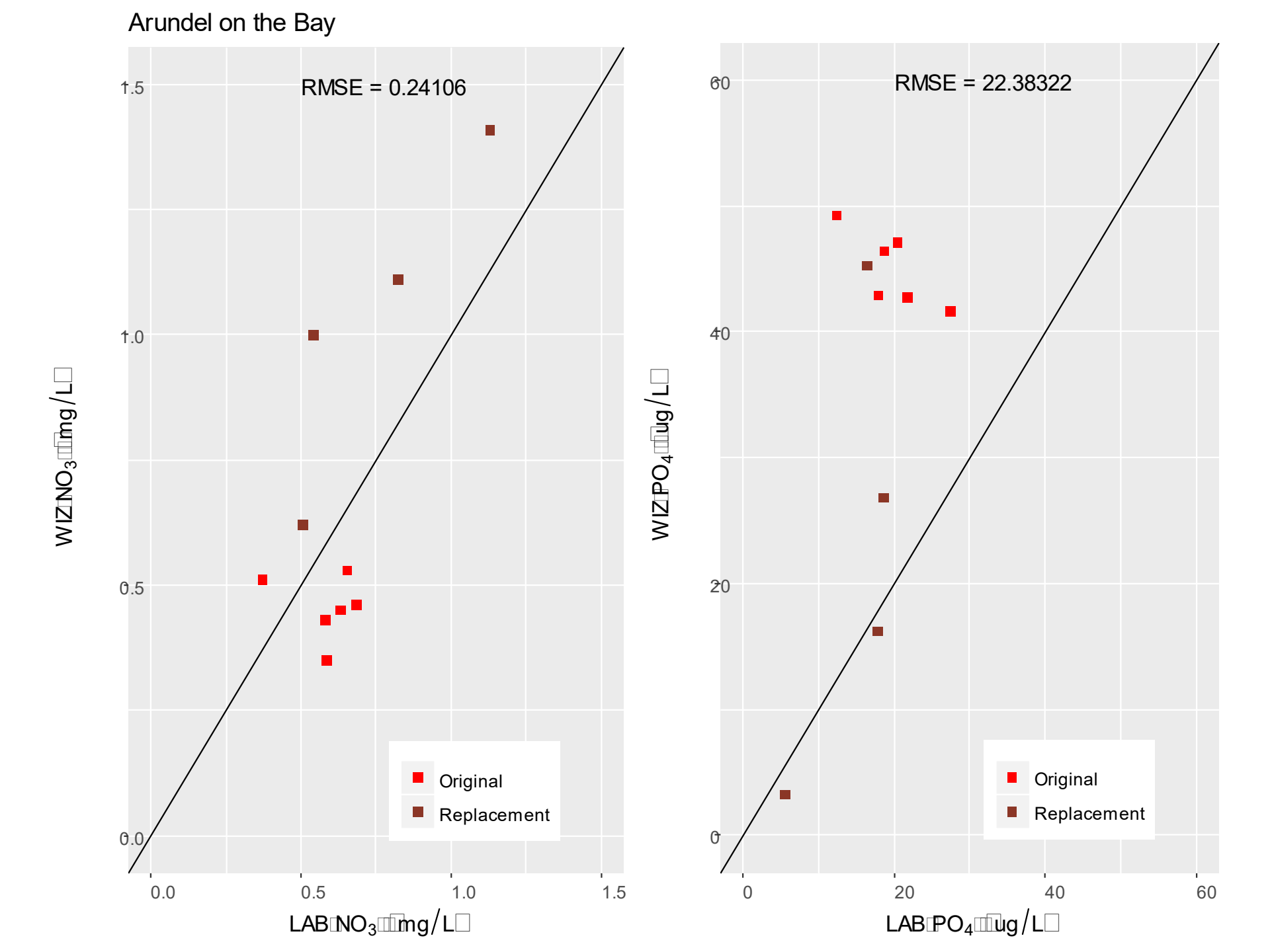
Miniaturized wet chemistry
Long-term deployments, but labor-intensive


Baltimore
Towson
Bel Air
Aberdeen
Elkton
Middle River
Chestertown
Glen Burnie
Centreville
Annapolis
Queenstown
Kent Island
Denton
St Michaels
Easton
Chesapeake Beach
Prince Frederick
Cambridge
Blackwater National Wildlife Refuge

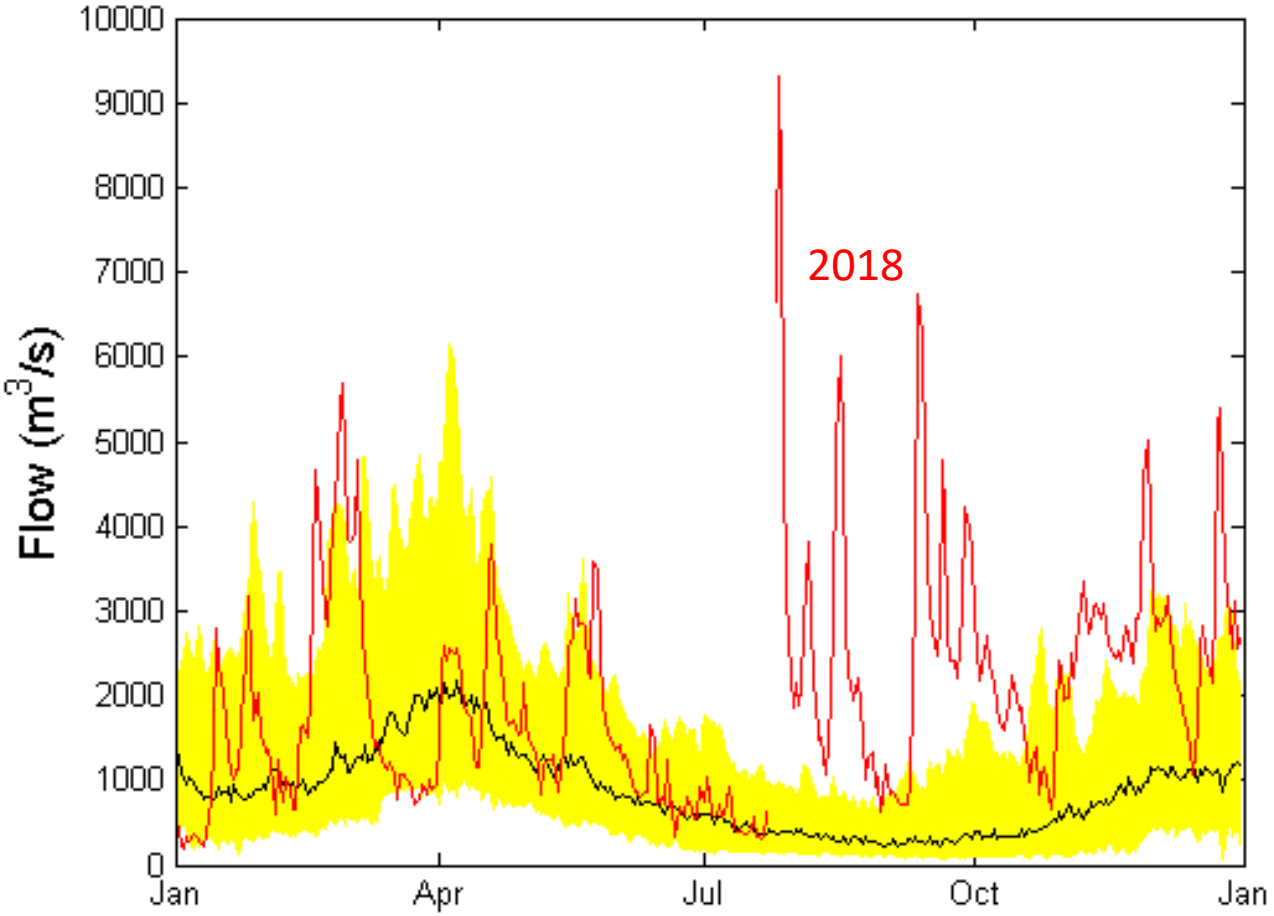

NO3 mg/L
2.0
1.5
1.0
0.5
0.0
Oct
Nov
Dec
Jan
AOB Nutrient Sensor
DAB Nutrient Sensor
SUNA Sensor


PO4 ug/L
60
40
20
0
Oct
Nov
Dec
Jan
2018 - 2019
AOB Nutrient Sensor
DAB Nutrient Sensor


Arundel on the Bay
Dare's Beach
NO3 mg/L
PO4 ug/L
2.0
1.5
1.0
0.5
0.0
60
40
20
0
Oct
Nov
Dec
Jan
Dec 17
Dec 24
Dec 31
2018 - 2019
AOB
DAB
Grab

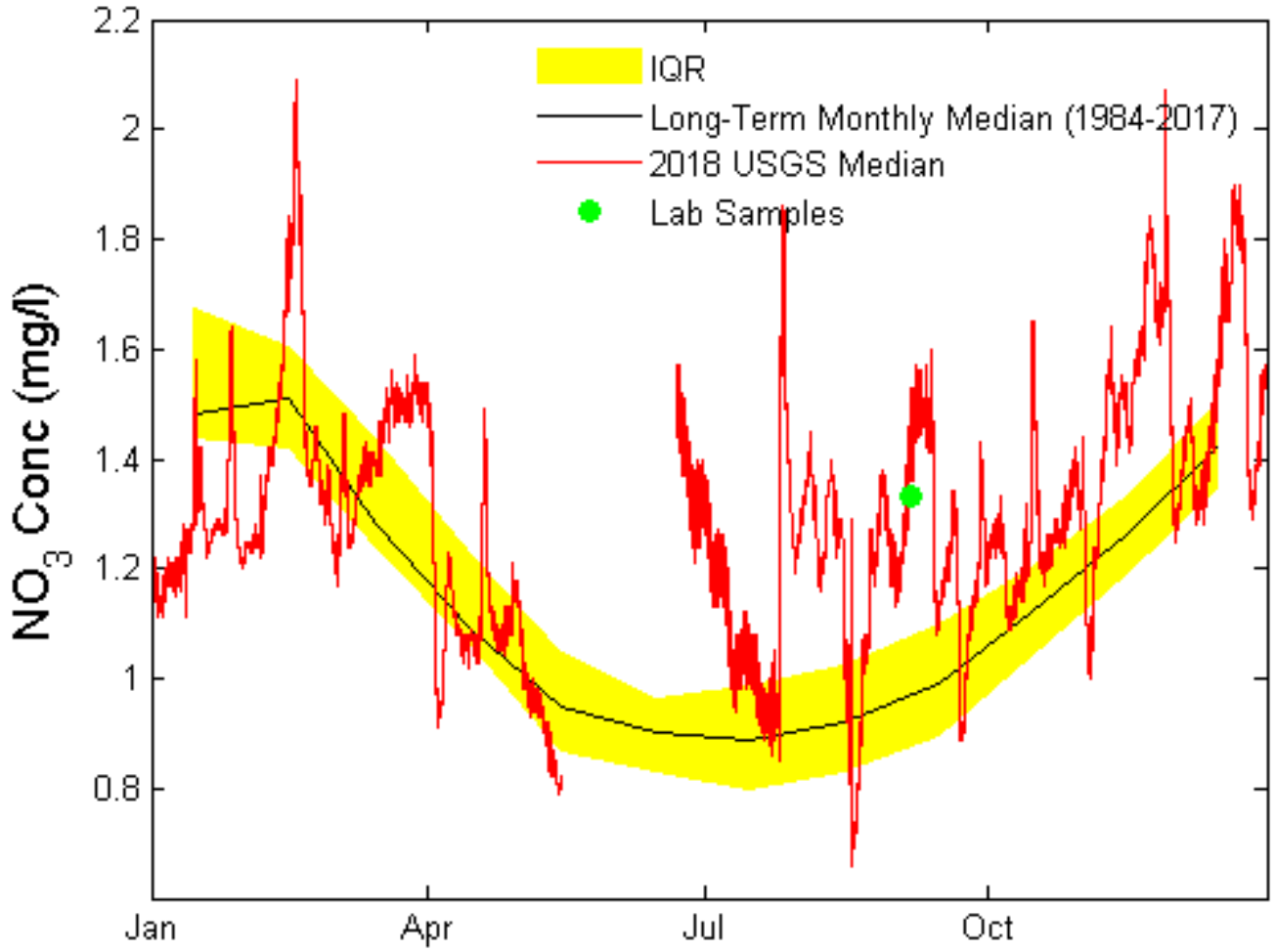

Arundel on the Bay
RMSE = 0.24106
WIZ NO3 (mg/L)
LAB NO3 (mg/L)
0.0
0.5
1.0
1.5
Original
Replacement
RMSE = 22.38322
WIZ PO4 (ug/L)
LAB PO4 (ug/L)
0
20
40
60
Original
Replacement

Susquehanna Flow

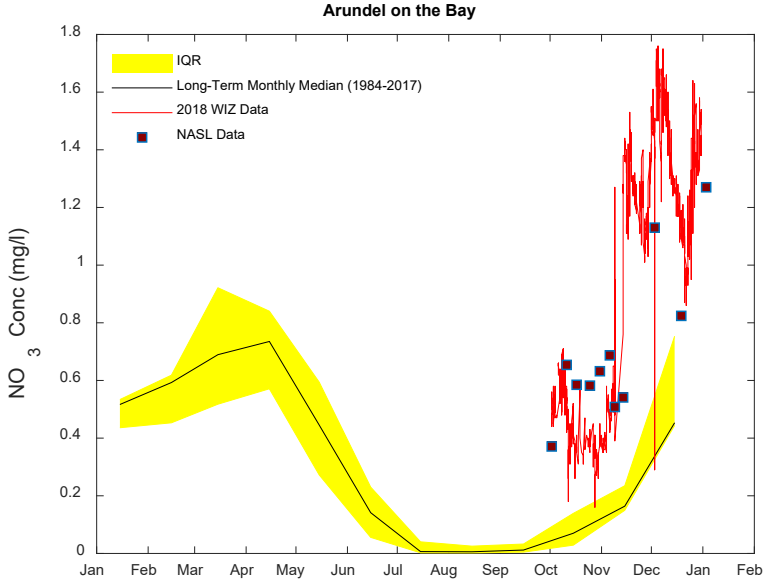


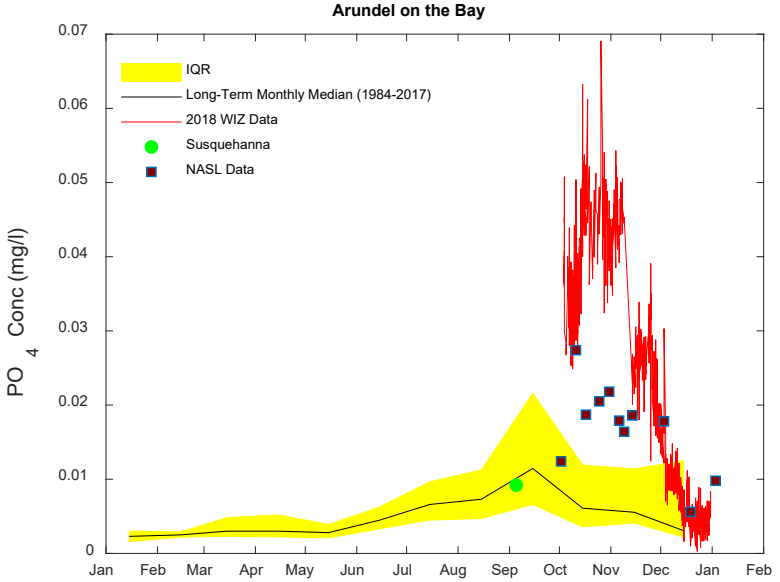
Black = Long Term Mean Yellow = IQR Red = 2018

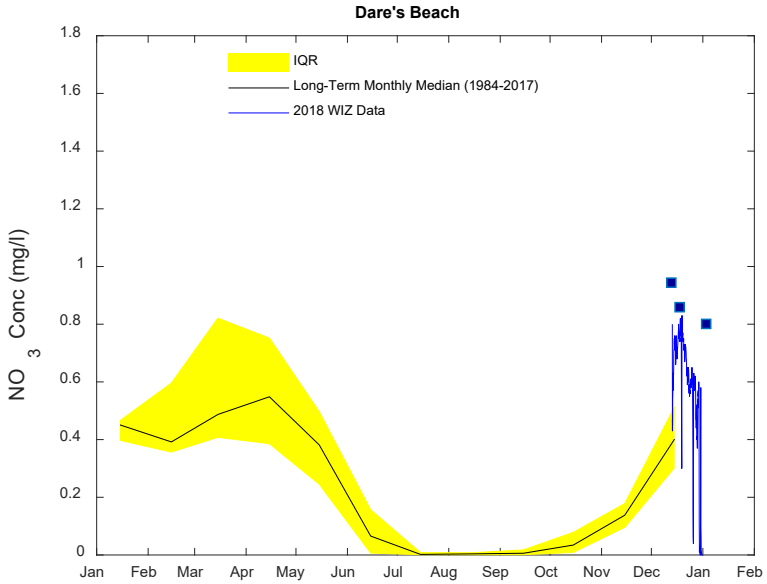
USGS SUNA Nitrate Sensor

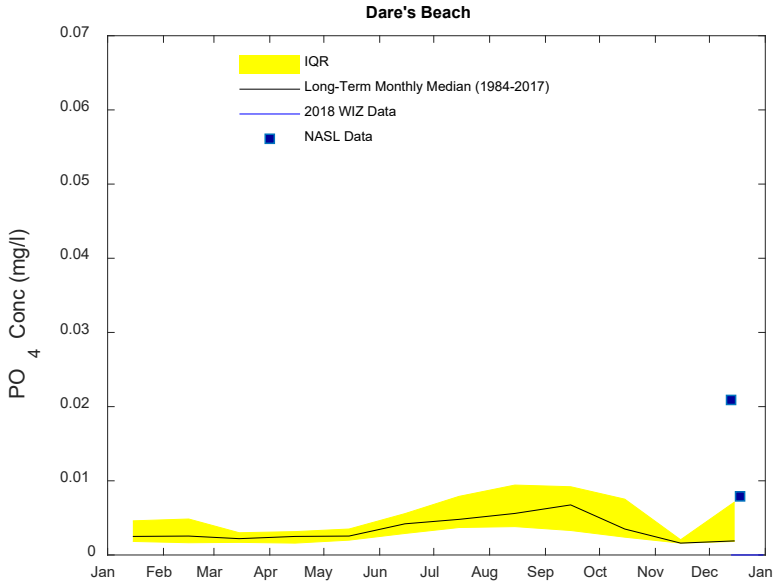


Wiz Sensors

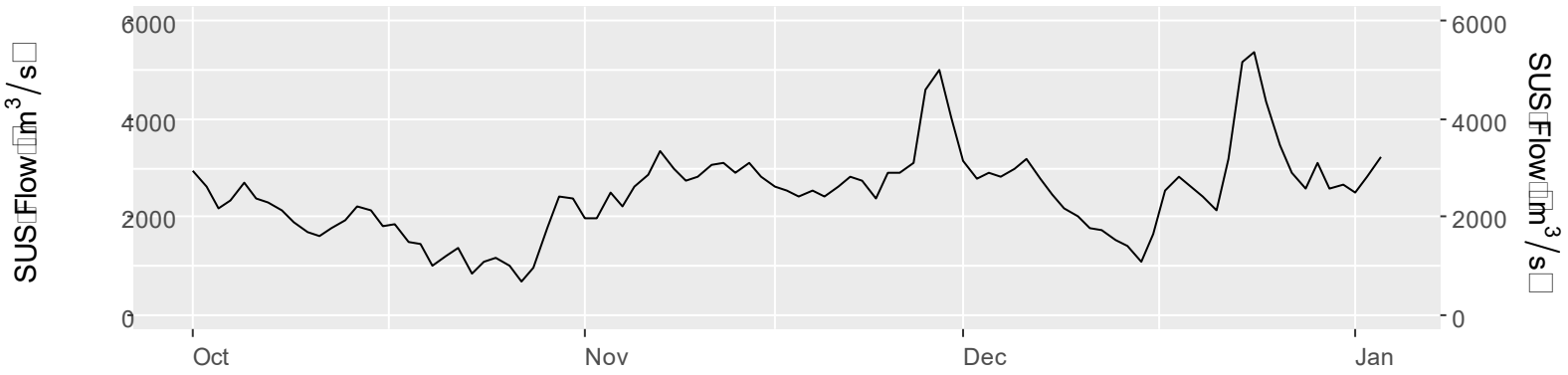

Arundel on the Bay
IQR
Long-Term Monthly Median (1984-2017)
2018 WIZ Data
NASL Data
NO 3 Conc (mg/l)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb

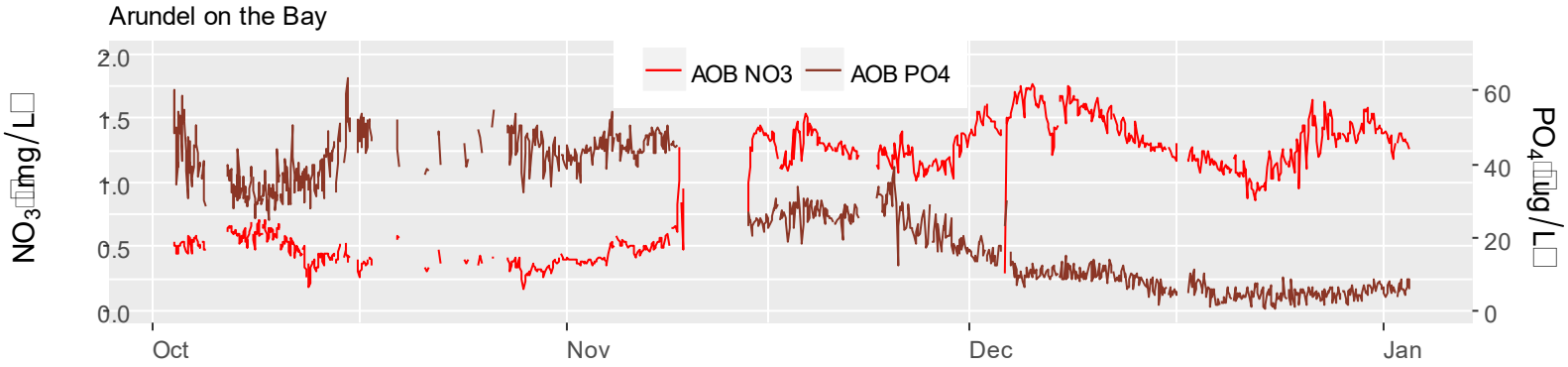

Arundel on the Bay
IQR
Long-Term Monthly Median (1984-2017)
2018 WIZ Data
Susquehanna
NASL Data
PO 4 Conc (mg/l)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb

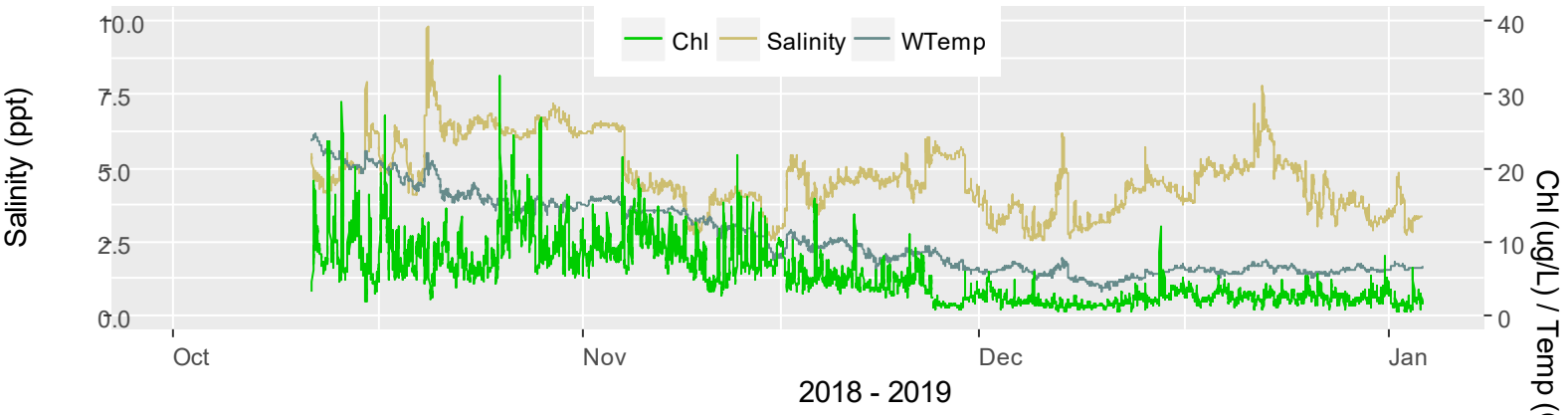

Dare's Beach
IQR
Long-Term Monthly Median (1984-2017)
2018 WIZ Data
NO 3 Conc (mg/l)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb


Dare's Beach
IQR
Long-Term Monthly Median (1984-2017)
2018 WIZ Data
NASL Data
PO 4 Conc (mg/l)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan

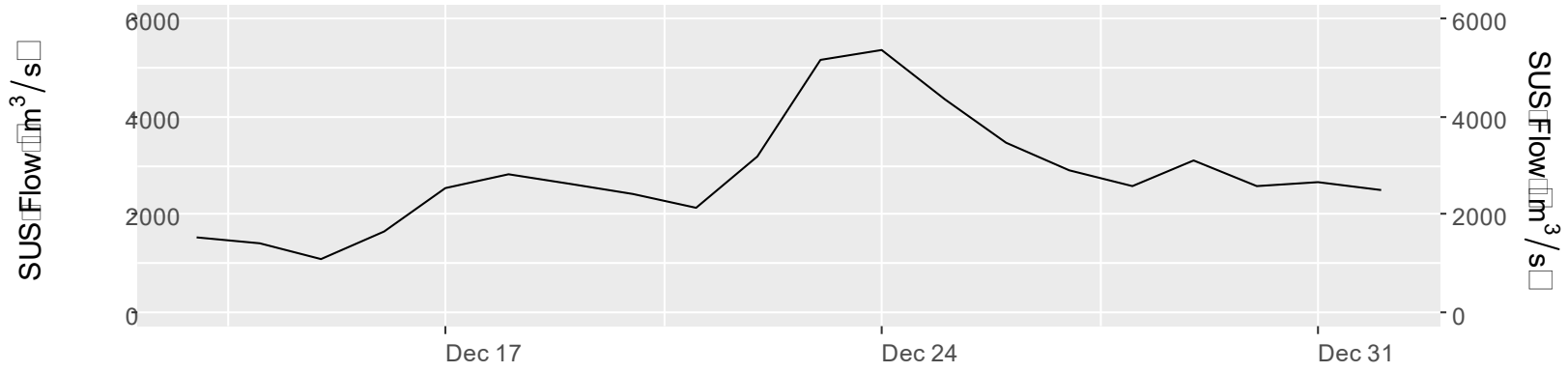
Arundel on the Bay – Ecological Insights?

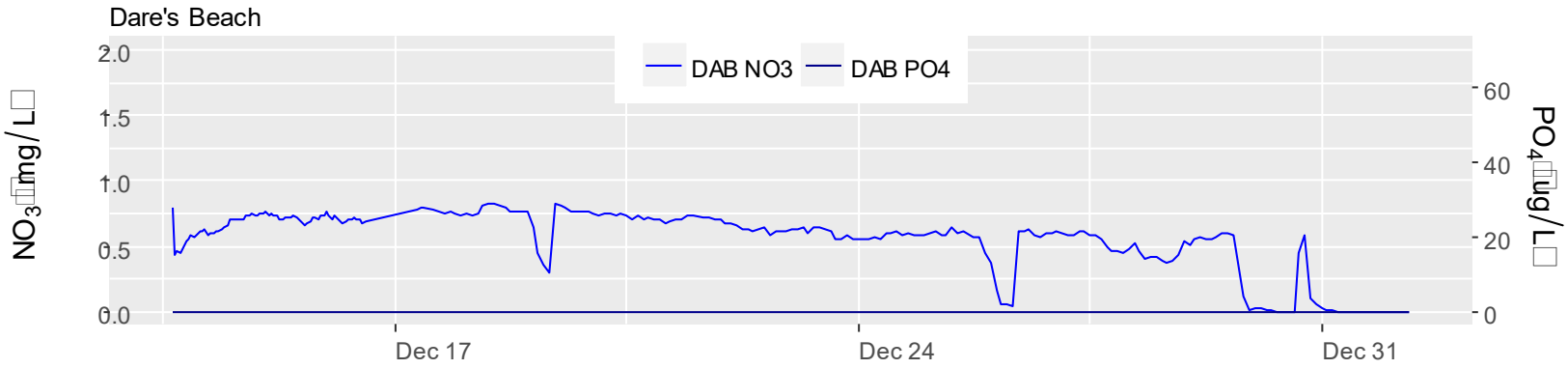


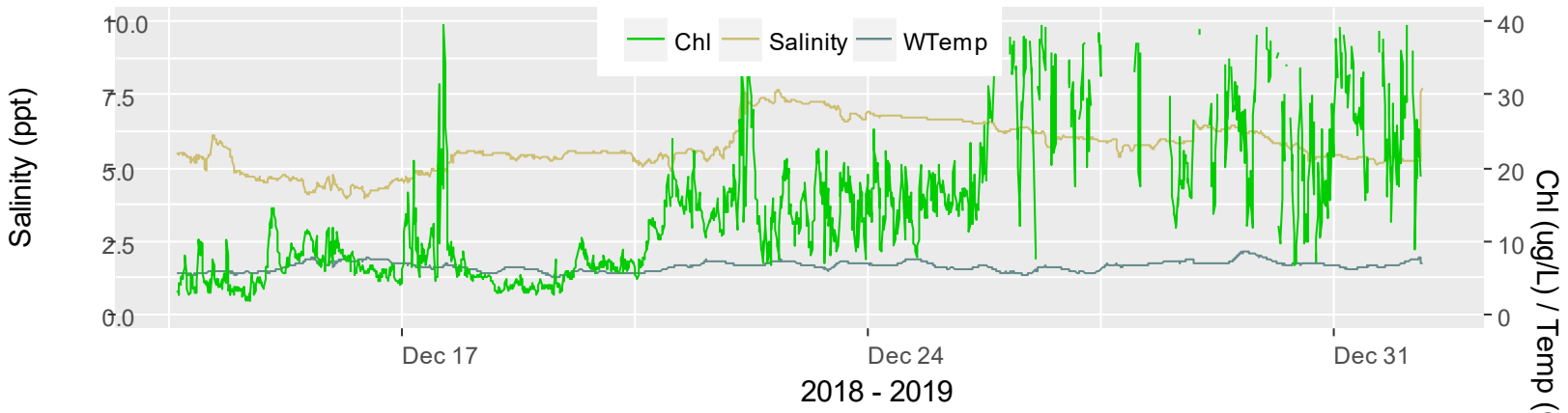




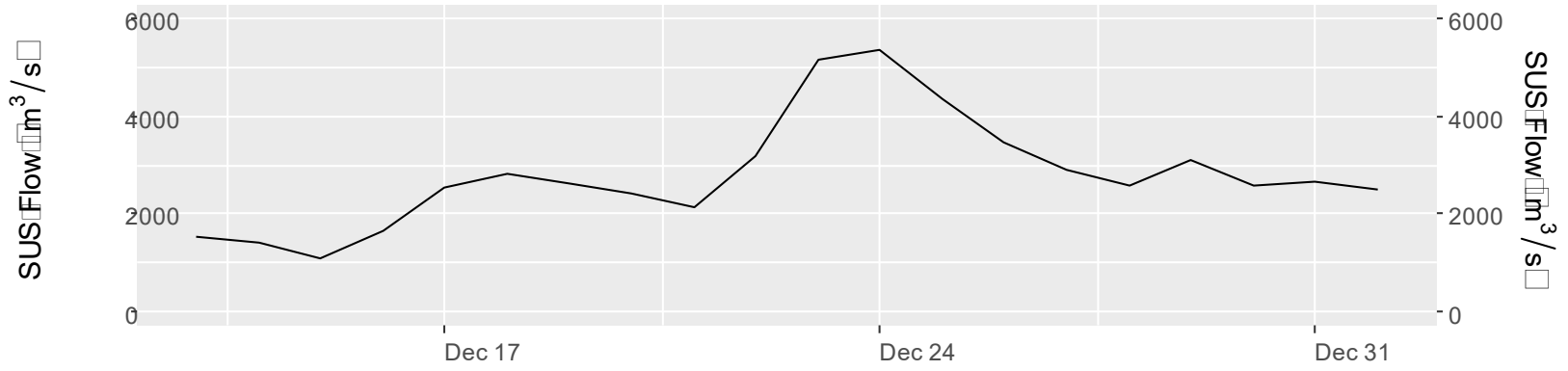
Dares Beach– Ecological Insights?

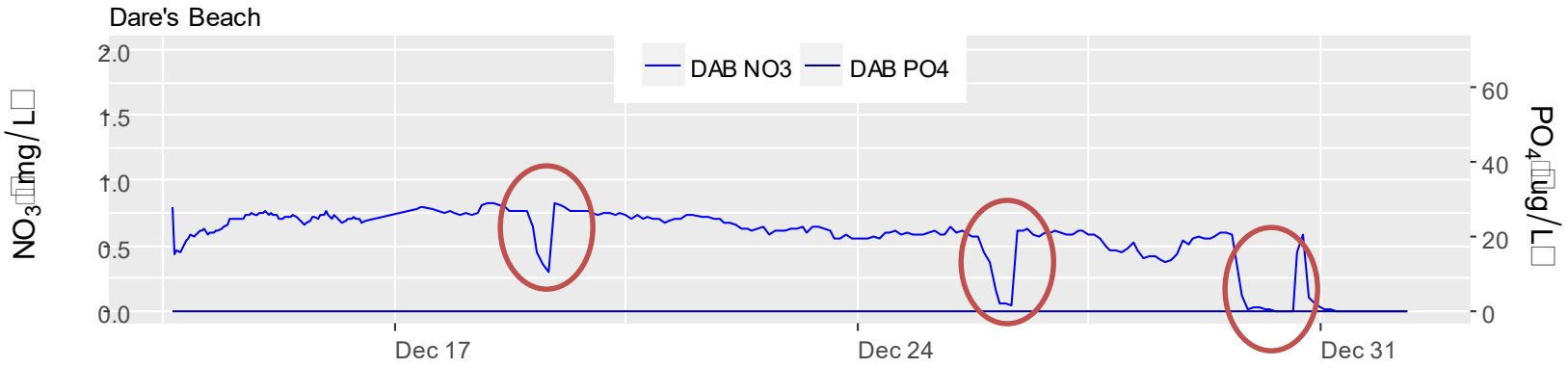


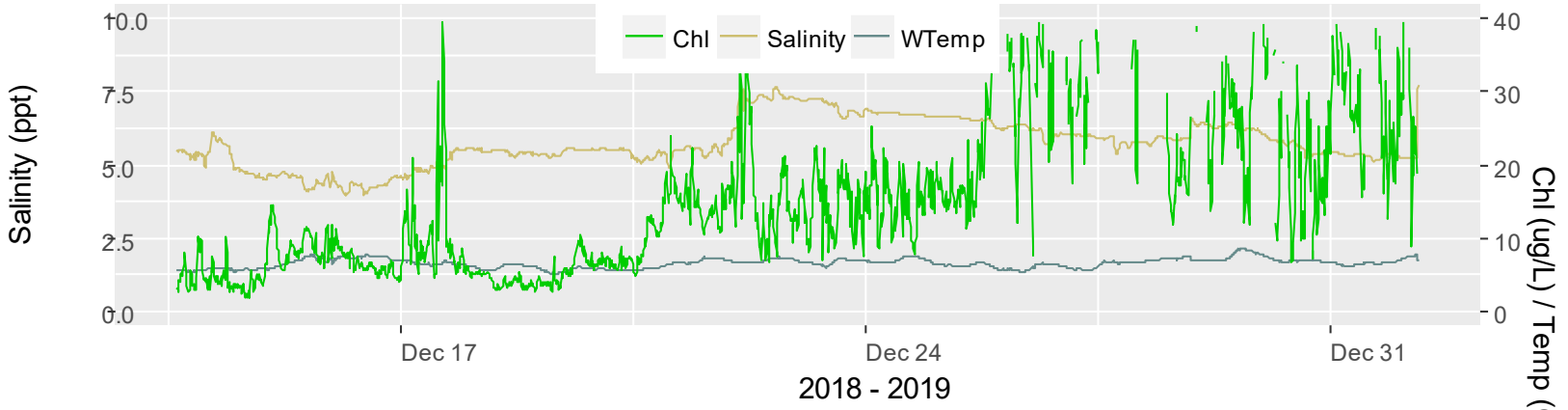


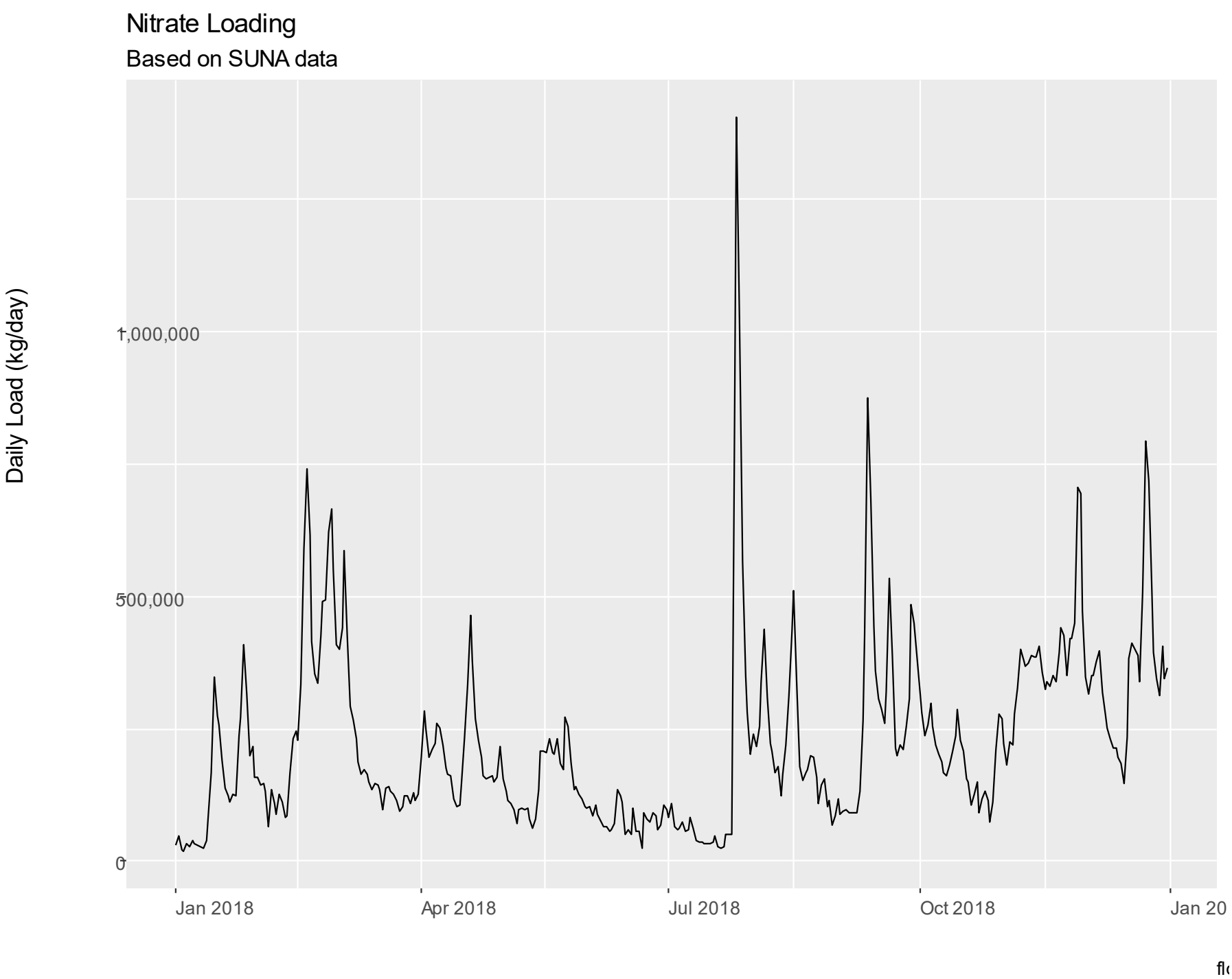


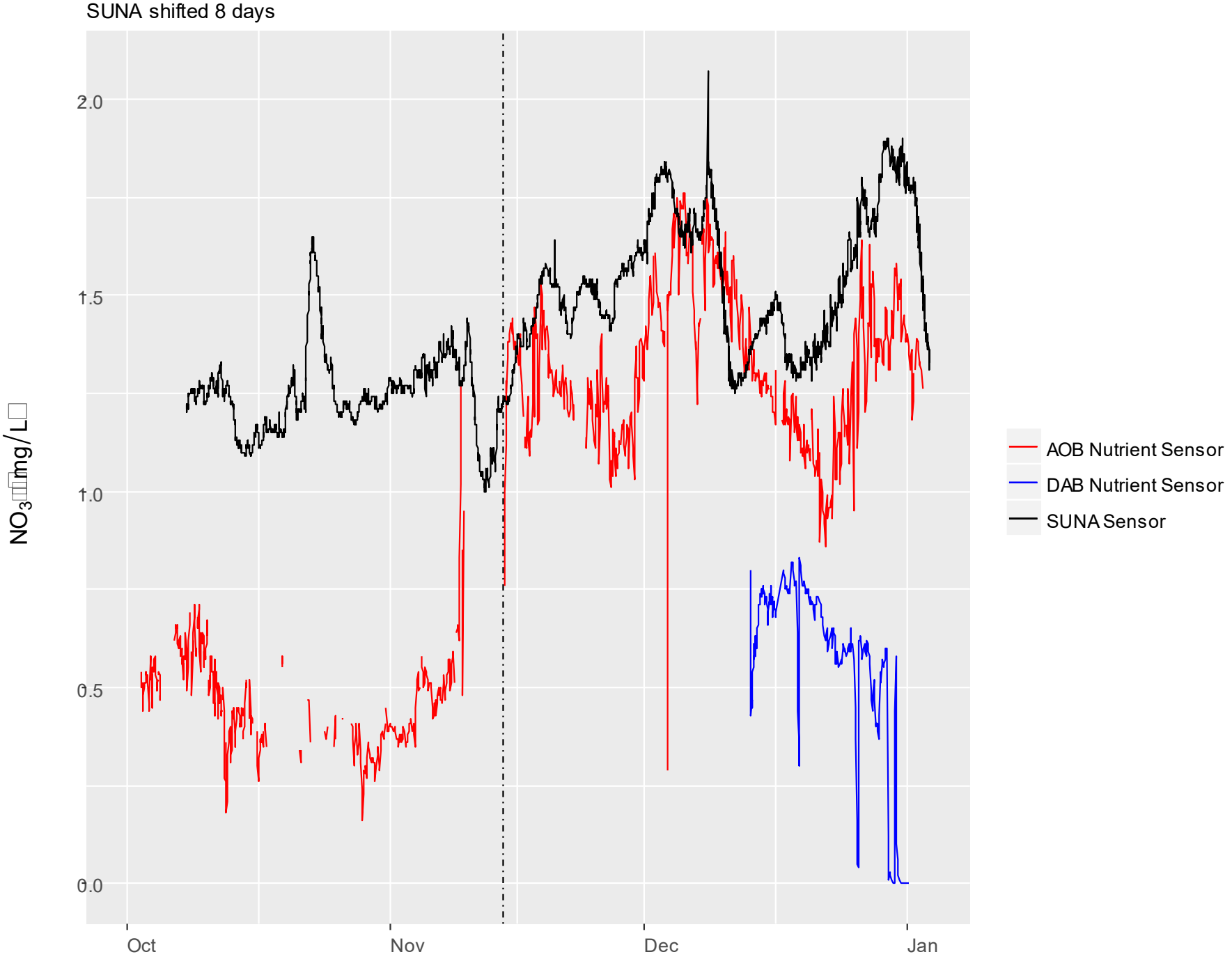
Dares Beach– Ecological Insights?

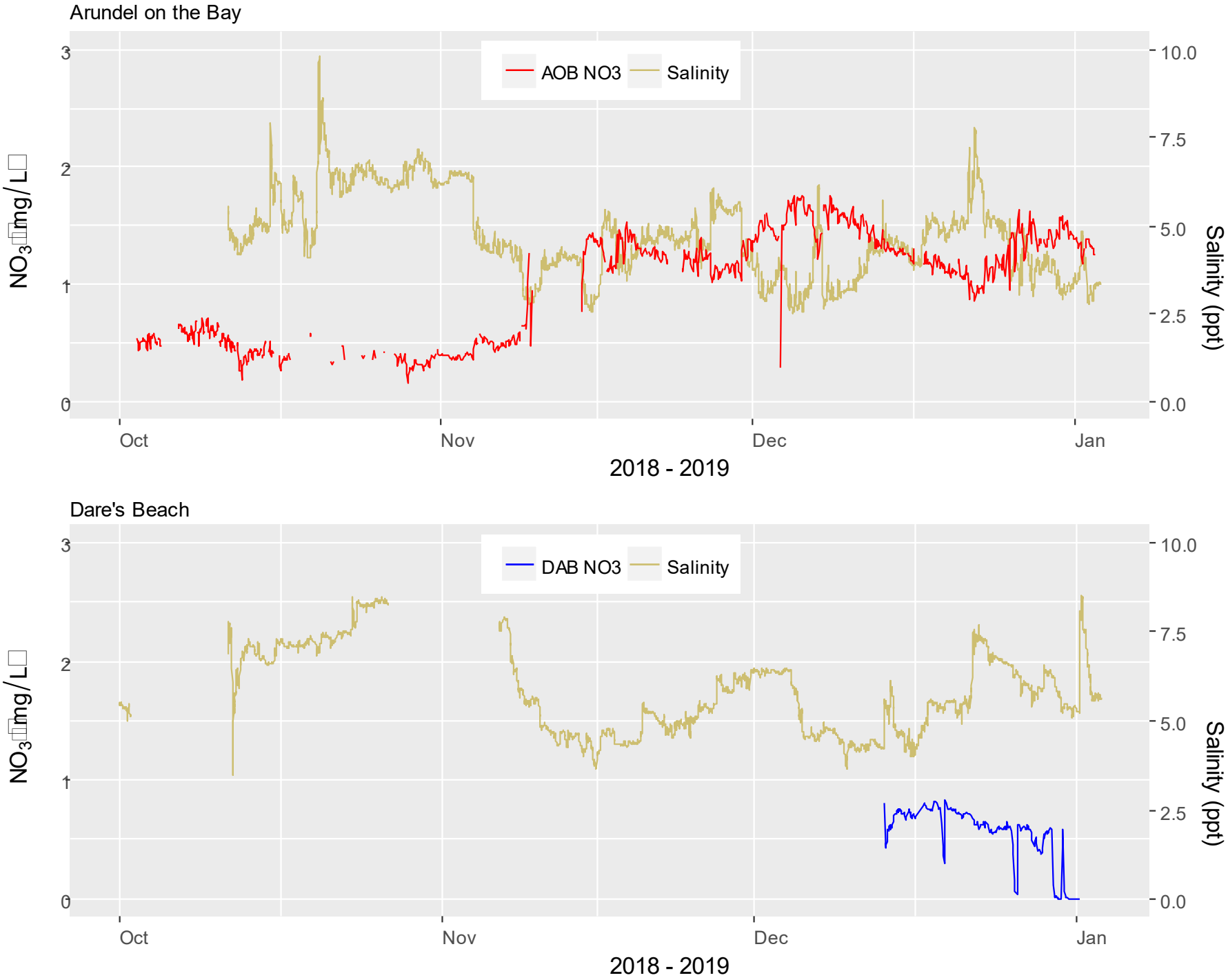







Nitrate Loading
Based on SUNA data
Daily Load (kg/day)
1,000,000
500,000
0
Jan 2018
Apr 2018
Jul 2018
Oct 2018
Jan 20


SUNA shifted 8 days
2.0
1.5
1.0
0.5
0.0
NO3 mg/L
Oct
Nov
Dec
Jan
AOB Nutrient Sensor
DAB Nutrient Sensor
SUNA Sensor


Arundel on the Bay
AOB NO3
Salinity
NO3 mg/L
Salinity (ppt)
0
1
2
3
0.0
2.5
5.0
7.5
10.0
Oct
Nov
Dec
Jan
2018 - 2019
Dare's Beach
DAB NO3
Salinity
NO3 mg/L
Salinity (ppt)
0
1
2
3
0.0
2.5
5.0
7.5
10.0
Oct
Nov
Dec
Jan
2018 - 2019

Maintenance Insights:

Costs

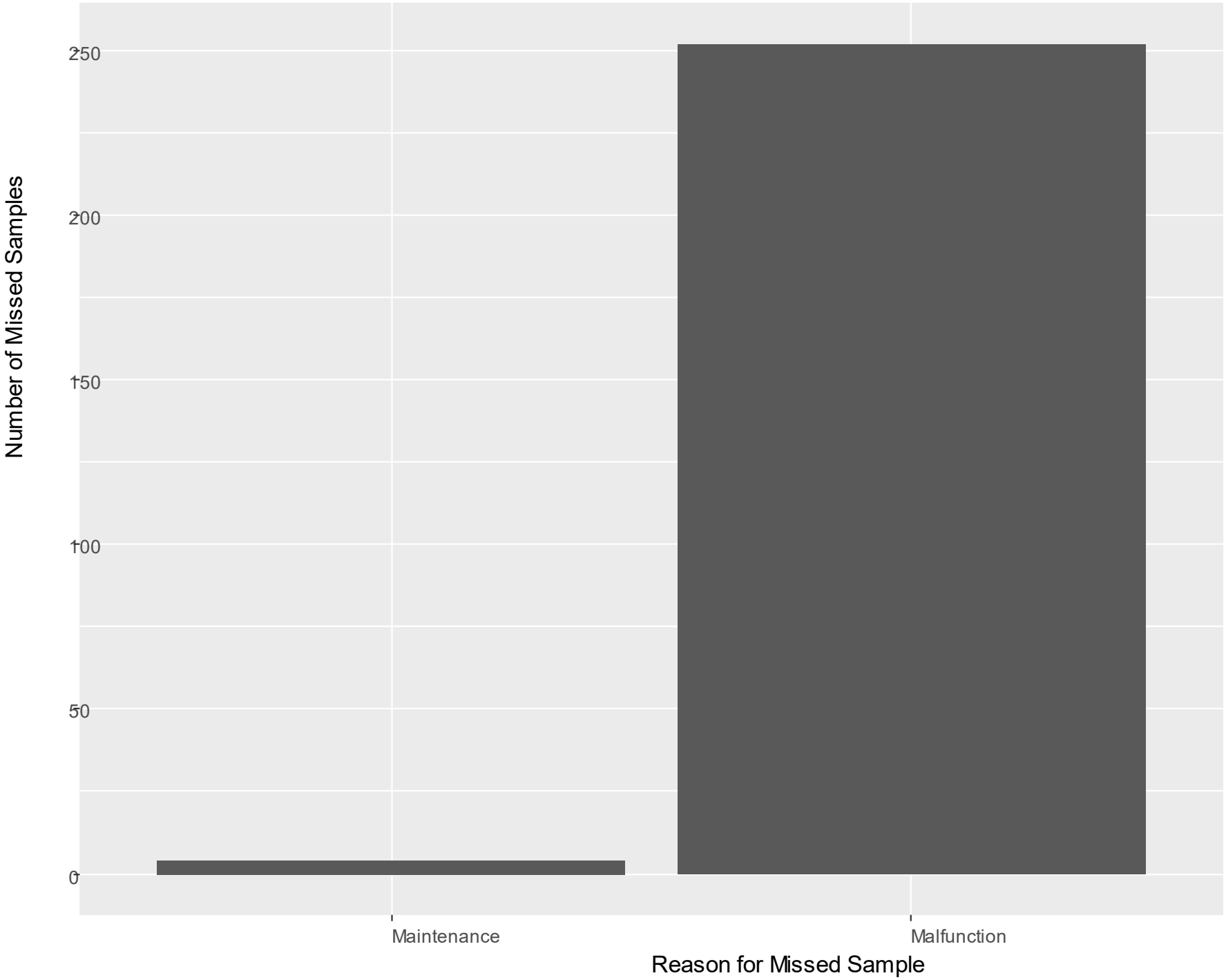
Chemicals :	$445 (for chemicals we didn't have)
Data plan :	? / month (for data transmission)

Site Visits

Planned Maintenance :	4 based on sampling frequency
Malfunction Response:	9 additional

Hours

Chemical Prep :	4 hours for initial reagent mixing
Maintenance day prep :	3 hours to fill canister and gather equipment/standards
Maintenance Day :	1.5 hours travel each way (75 miles)
	2 hours on site for cleanup and calibration check
Post Maintenance Day :	3 hours to empty/clean used canister and waste bag
Malfunction Trouble Shooting :	14 (total) additional to normal maintenance on site
Total hours dedicated :	250 for everything involved


Number of Missed Samples
250
200
150
100
50
0
Maintenance
Malfunction
Reason for Missed Sample

Ecological Insights:

- Sensors useful for tracking temporal shifts in response to flow events
- Documented variability will be useful for understanding estuarine responses on time scale better suited to modeling and continuous sensor data
- Maintenance is a challenge and calibration data still indicates “proceed with some caution”
- Susquehanna inputs impacted main stem of bay on short time scales this summer (~8 days) – how does this compare to other years with lower flow?

Thank you!

SYSTEA

MARYLAND DEPARTMENT OF NATURAL RESOURCES

University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE
CHESAPEAKE BIOLOGICAL LABORATORY