King County

July 19th, 2017

Nutrient and Phytoplankton Trends and Dynamics in Central Puget Sound

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King County Dept. of Natural Resources & Parks
Water and Land Resources Division

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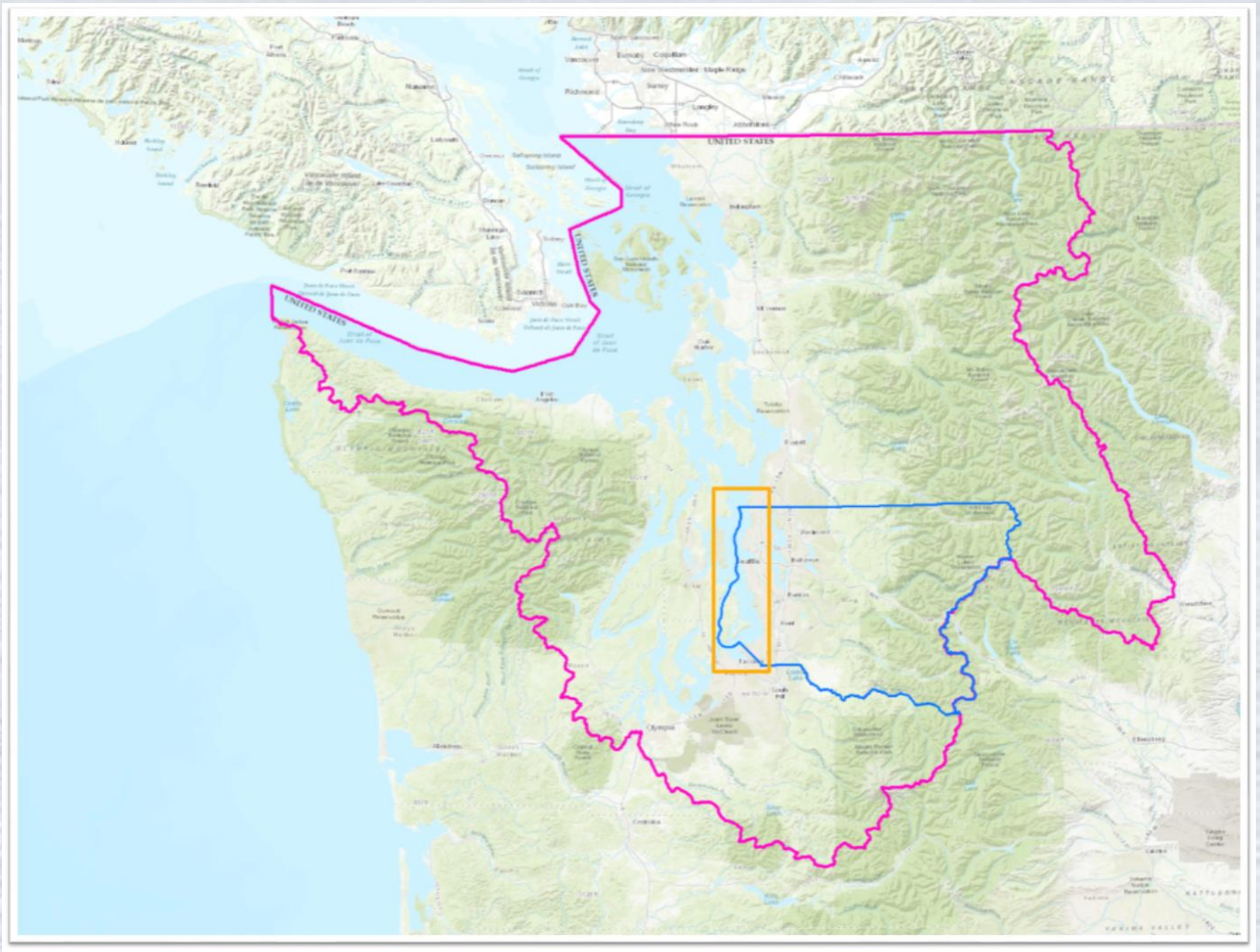
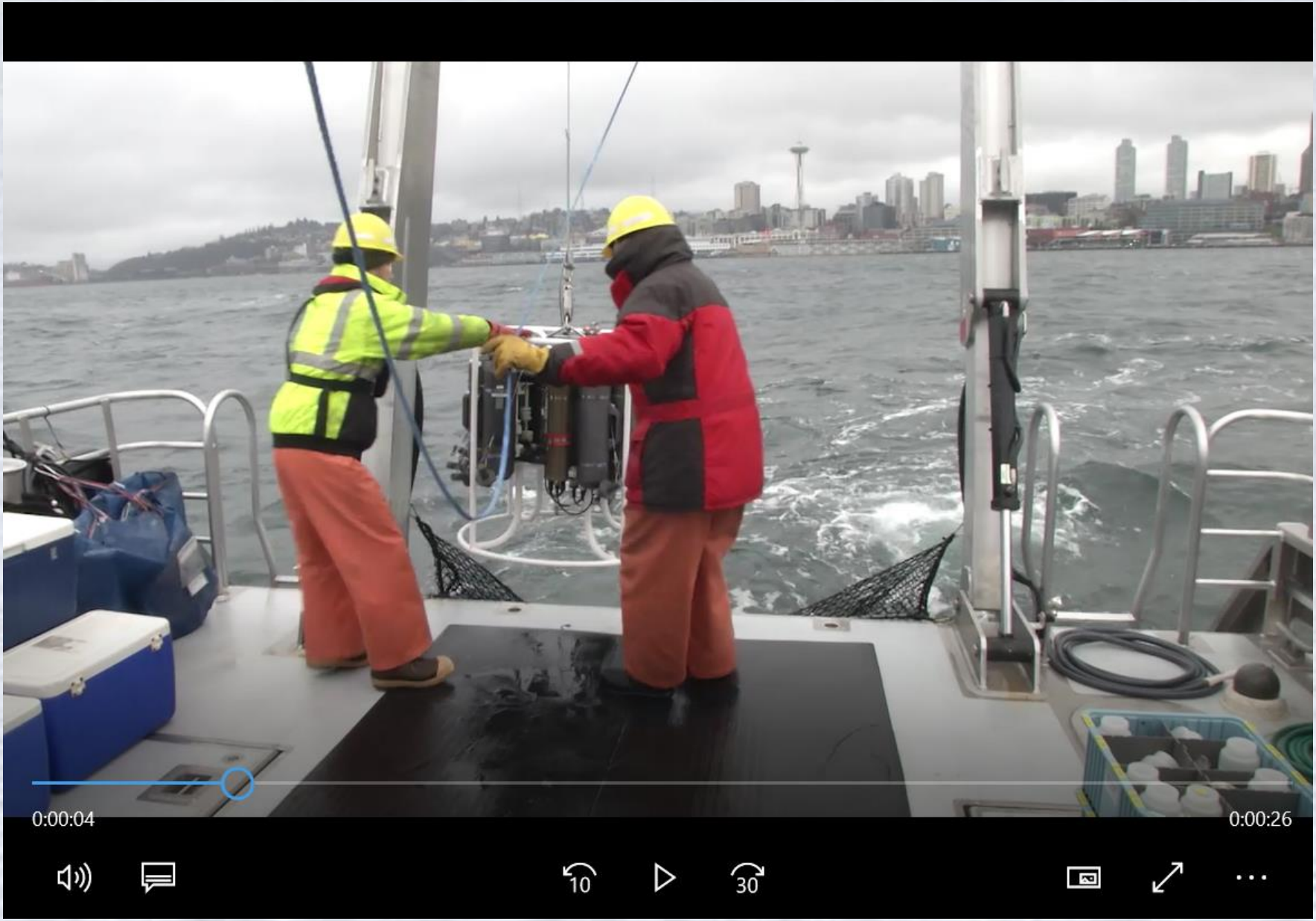


(Source: King County DNRP GIS Group)

How Do We Monitor Water Quality?

- **Offshore waters: *1994***
  - ***CTD Sensors & Discrete Data***
- **Beach waters: *1999***
  - ***Discrete Data***
- **Moorings: *2008***
  - ***Automated sensors sample every 15-min***
- **Phytoplankton: *2008***
  - ***Semi-Quantitative and FlowCam since 2014***
- **Zooplankton:*2014***
- **Sediments (offshore and beach)**



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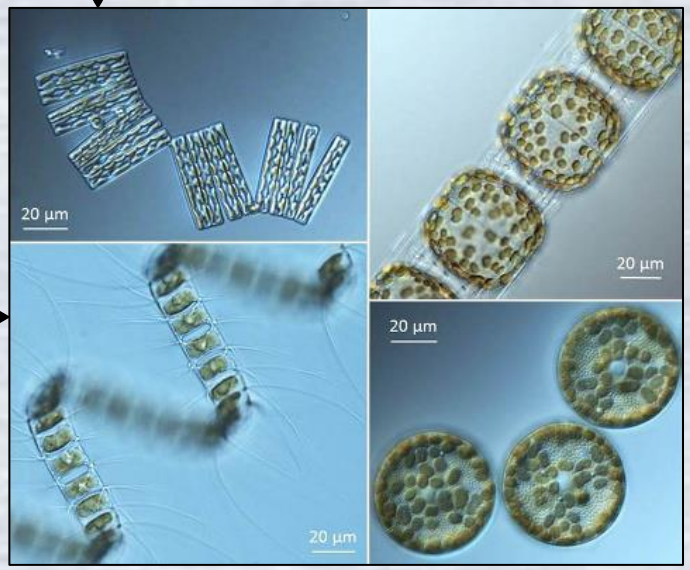
Temperature, Salinity
(Water Column Stability)

Nutrients

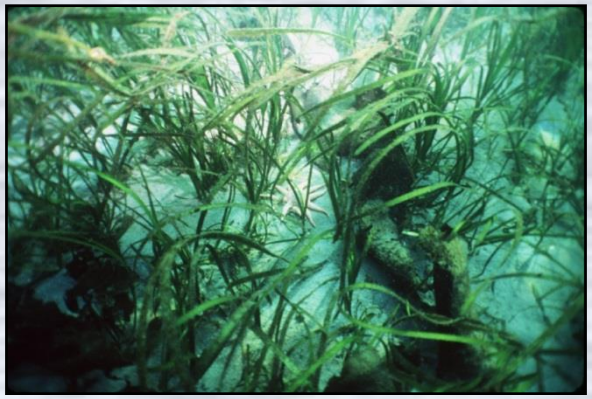
Nitrogen
- Nitrate+Nitrite
- Ammonia

Phosphorus

Silica



CO_2



Note: Silica inputs come from oceanic and land sources, and do not have an anthropogenic component like nitrogen and phosphorus.

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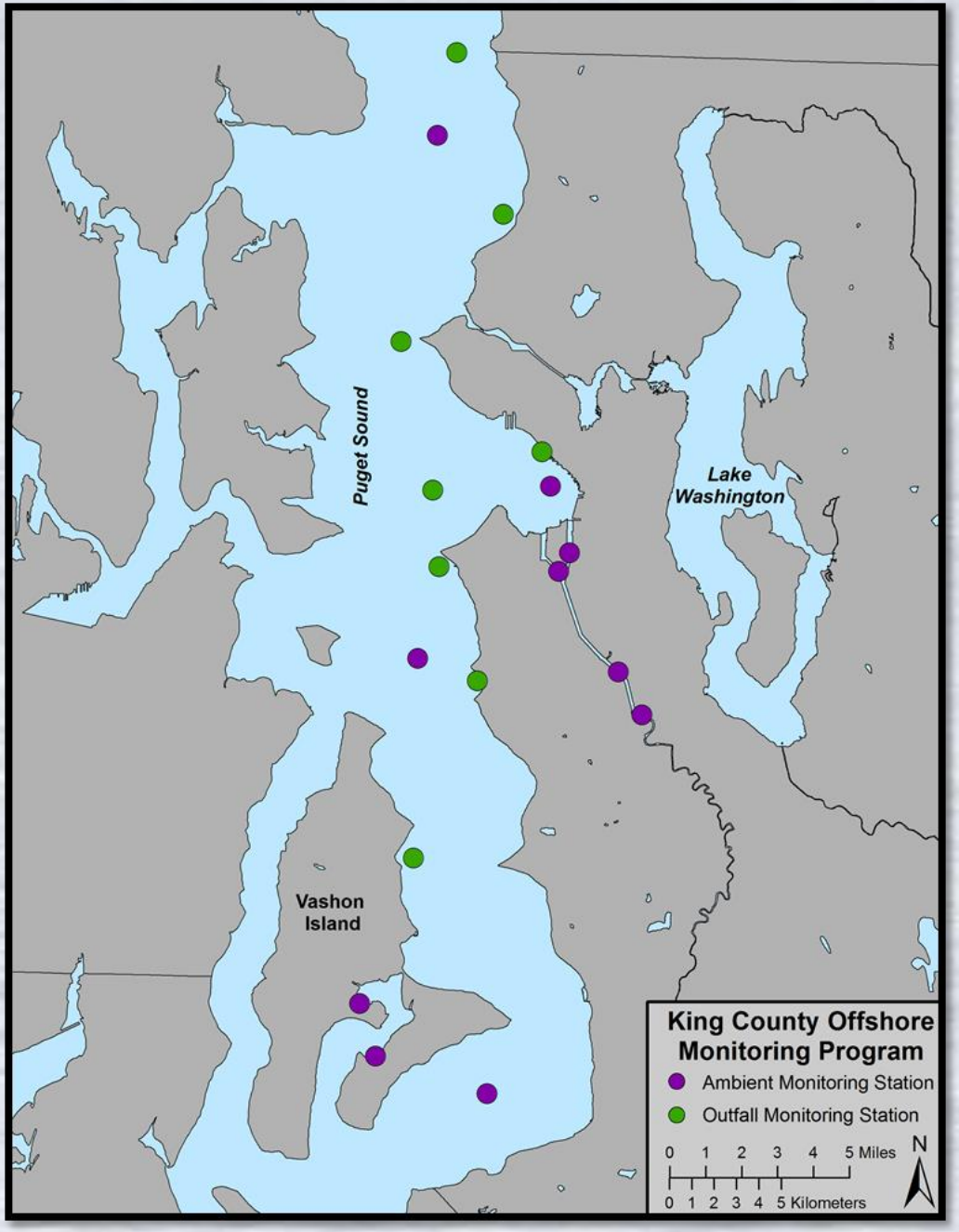
Offshore Sites



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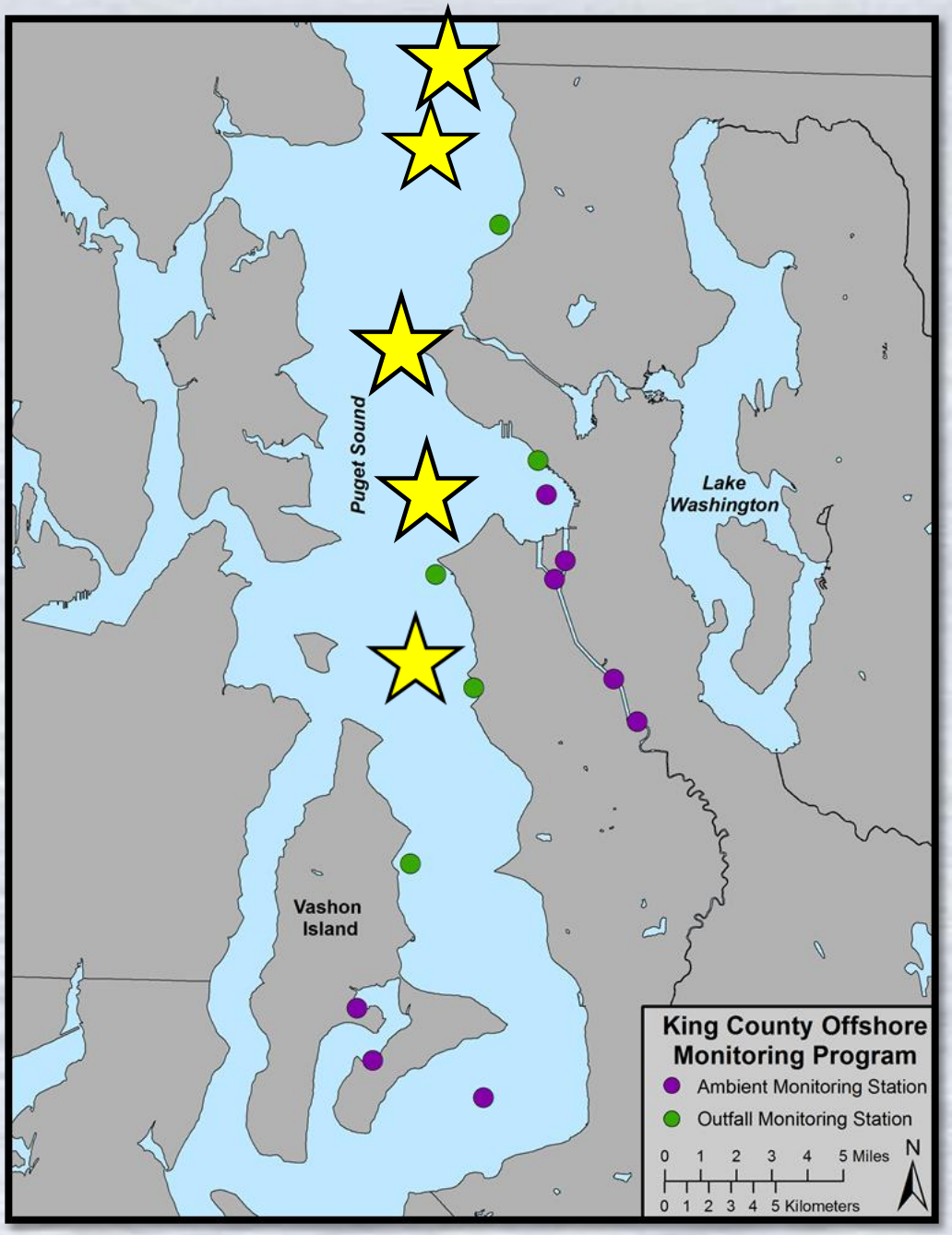
Offshore Sites

- Yellow stars – Trend analysis focused primarily on these deep stations (>60-m) that have a consistent long-term record



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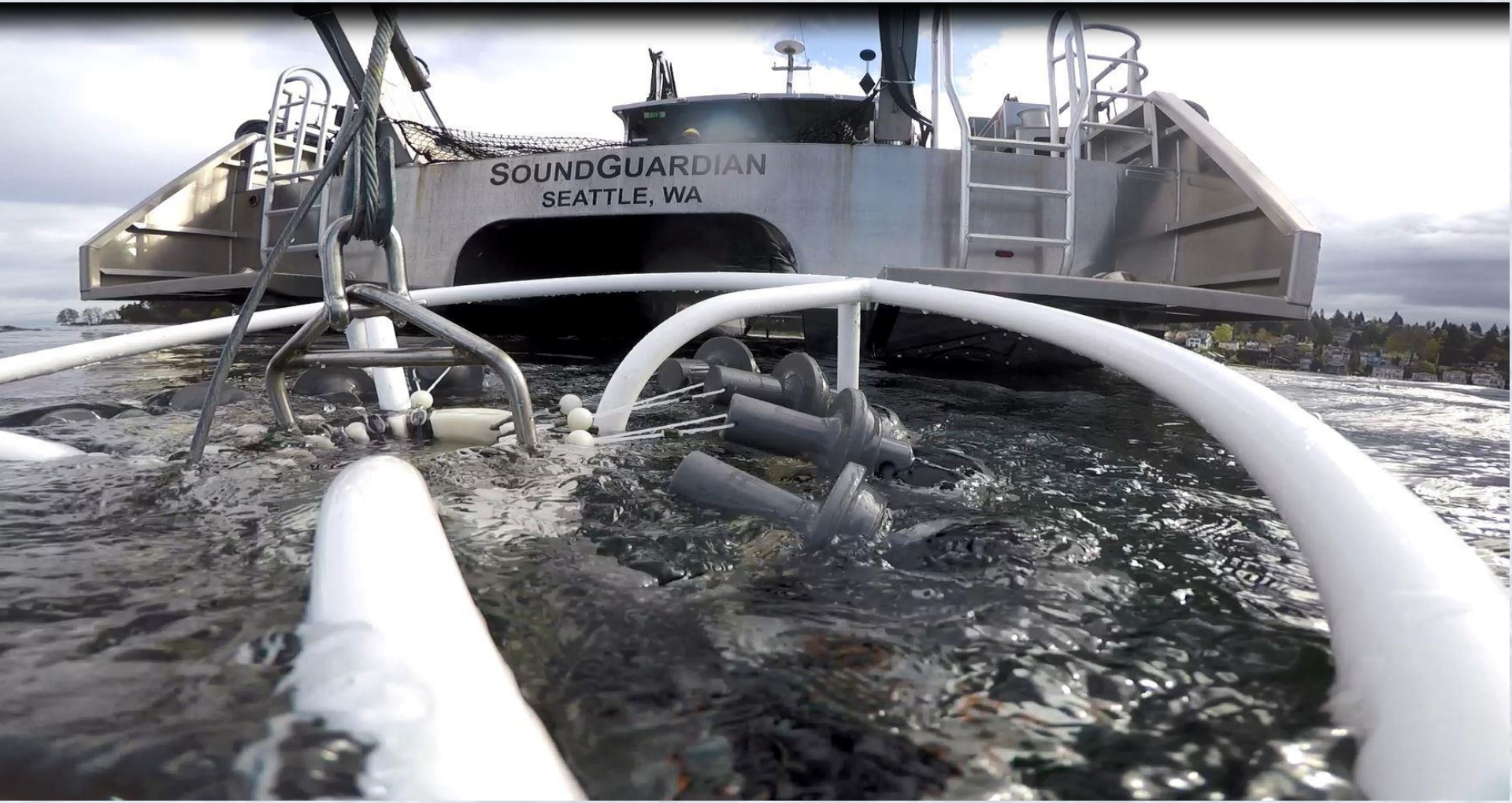
Near-Surface in Offshore Sites



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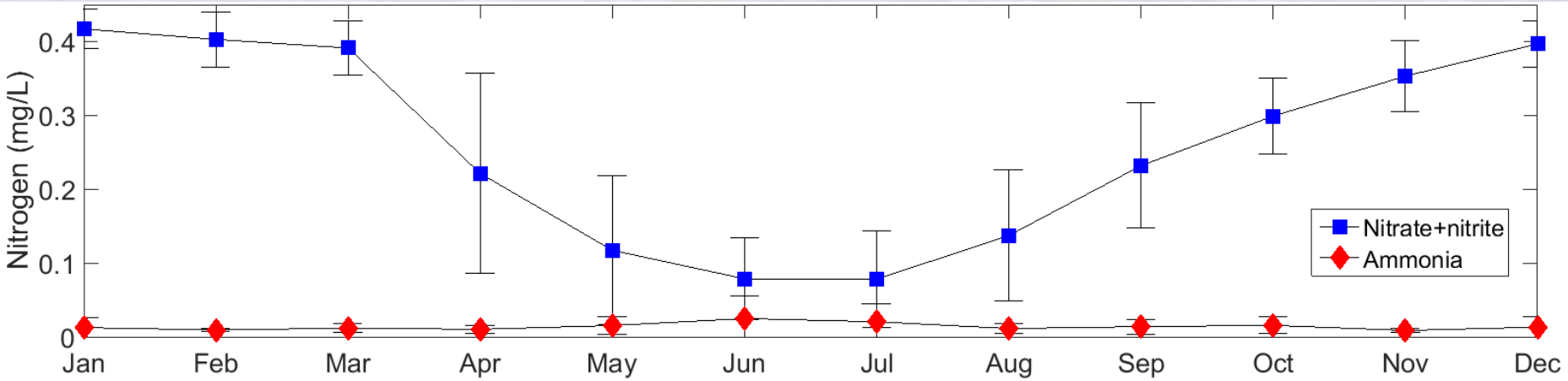
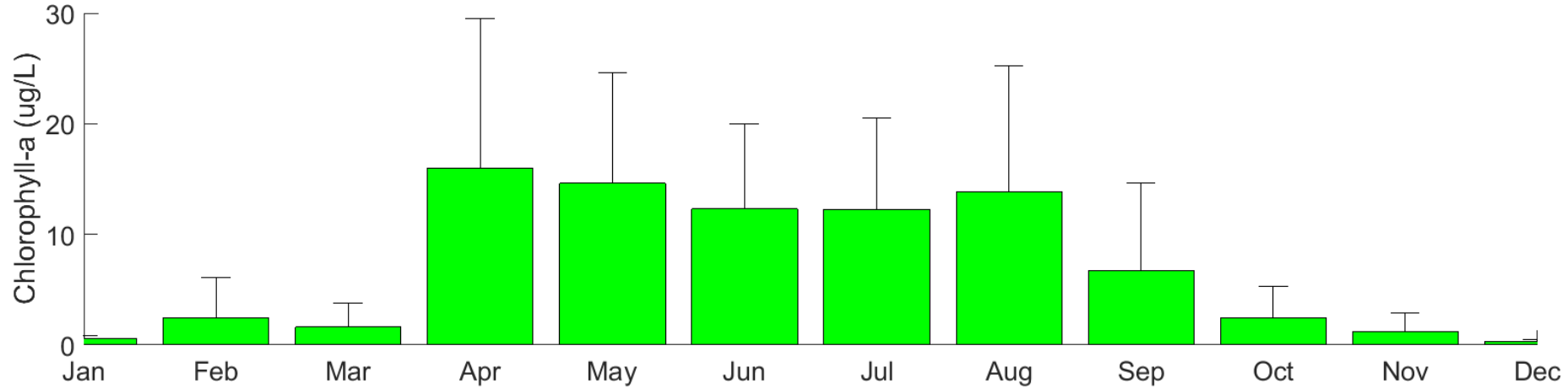
Seasonal Patterns by Month

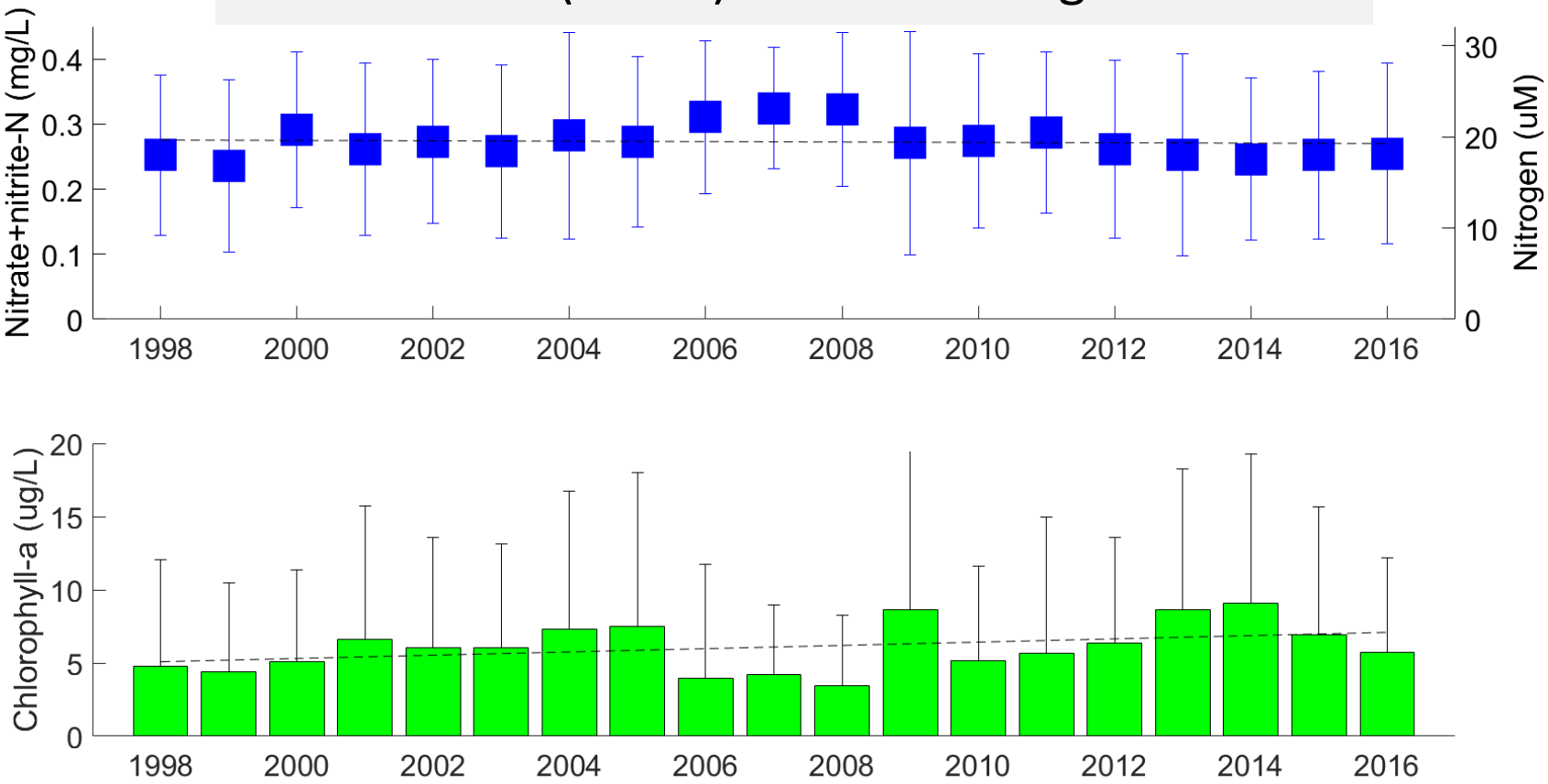
- Nutrient concentrations driven by phytoplankton uptake at the surface

Pt. Jefferson Near-Surface (<2-m) Monthly Average (1994 – 2016)



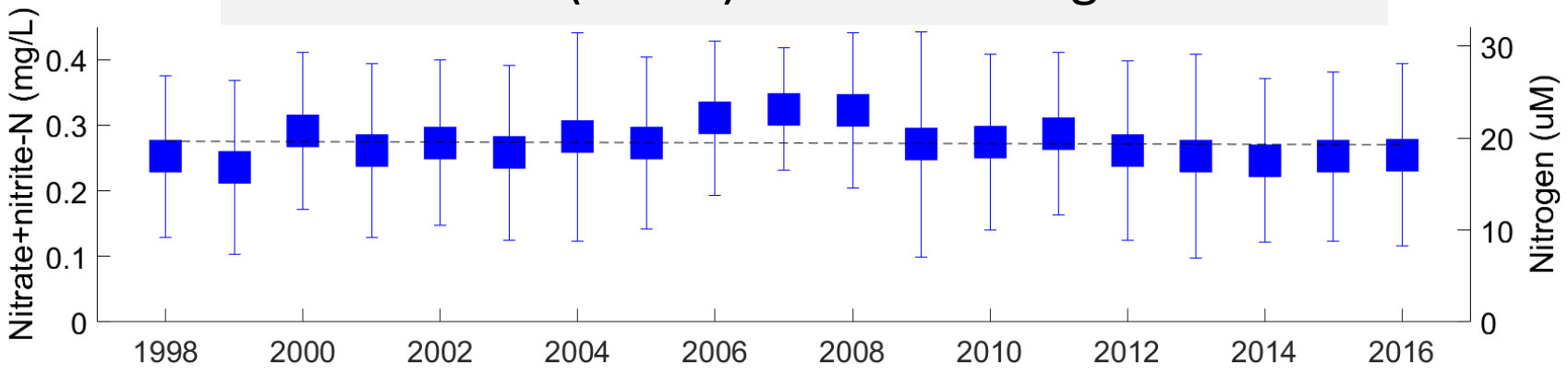


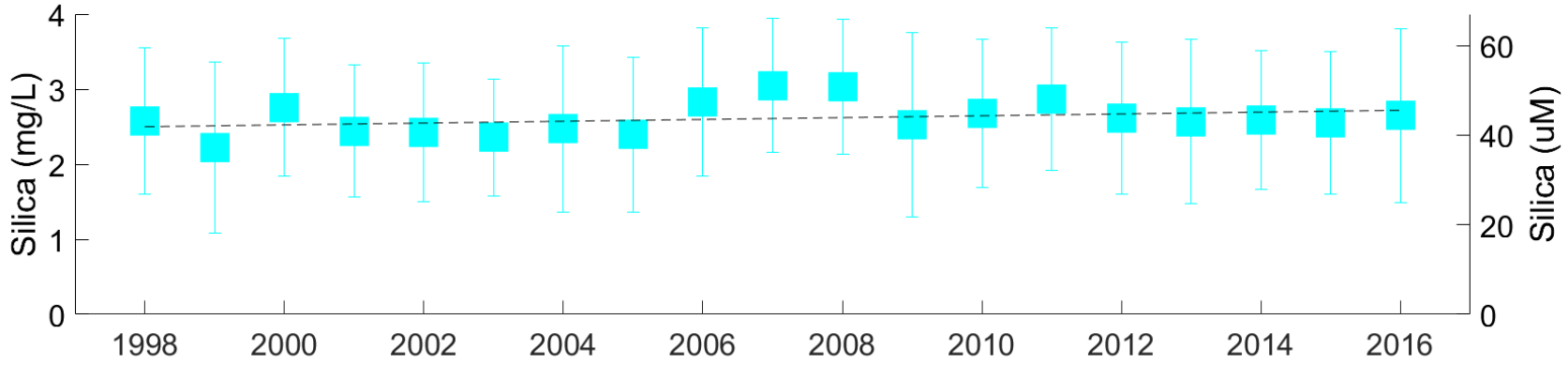
Near-Surface (< 2-m) Annual Average

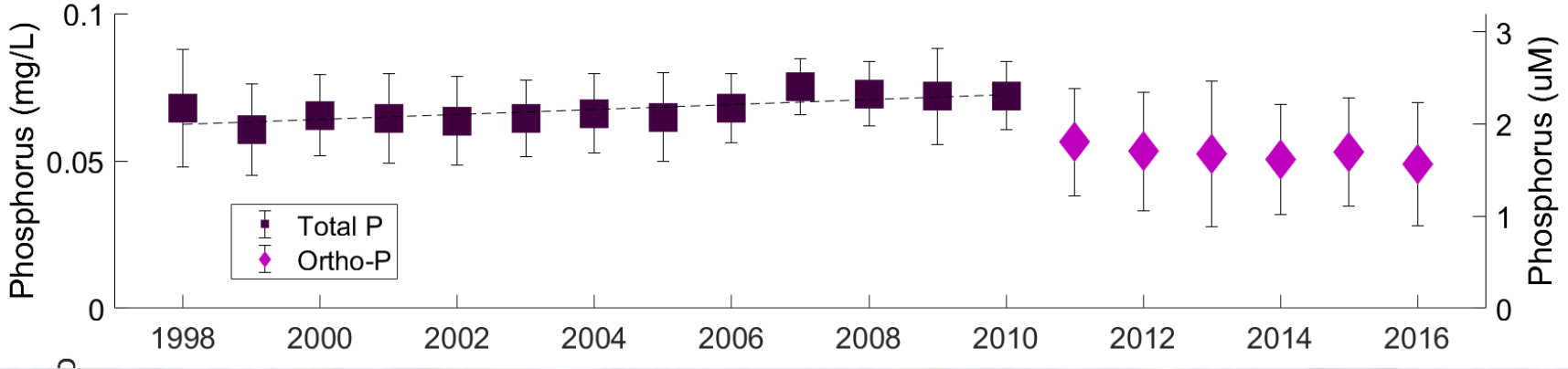


- Note inter-annual variability and connection between chlorophyll and nitrate observations within each year, such as 2006 - 2008. Bars show one standard deviation from annual means.

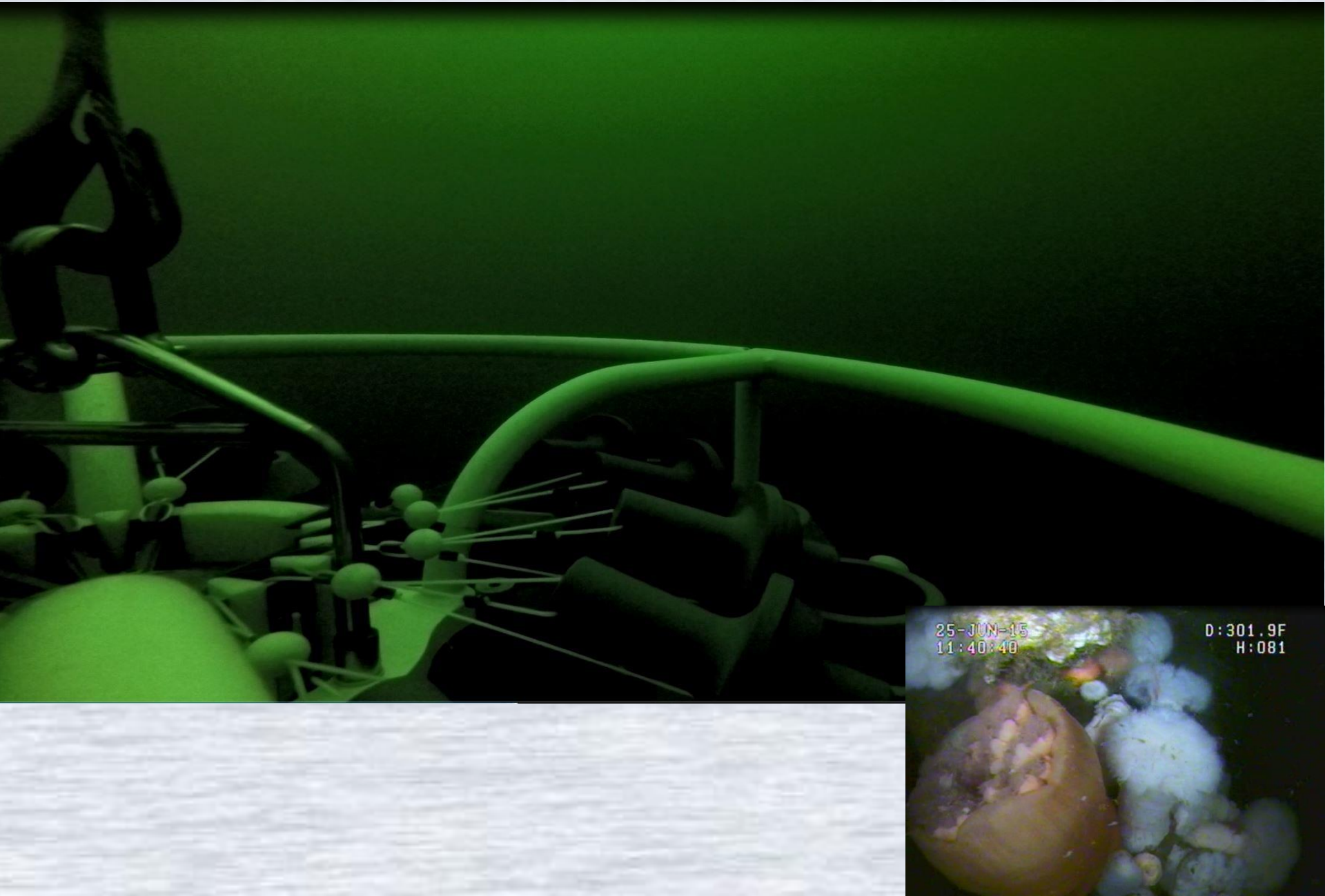
Near-Surface (< 2-m) Annual Average



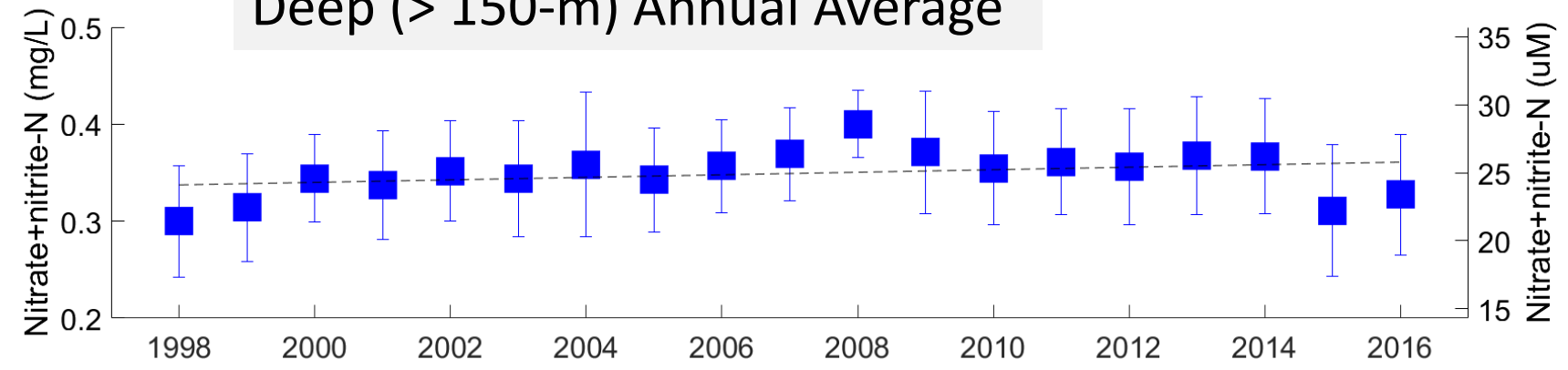


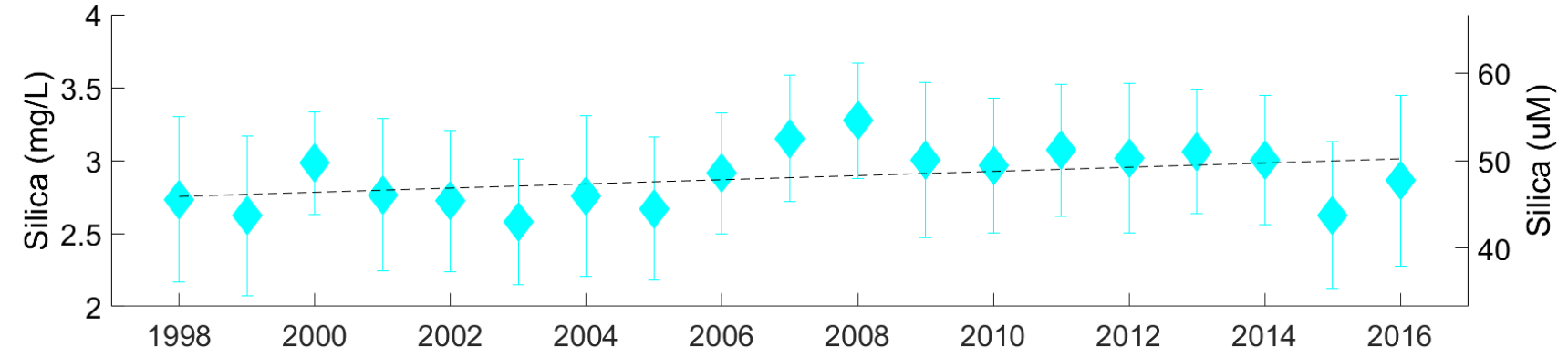


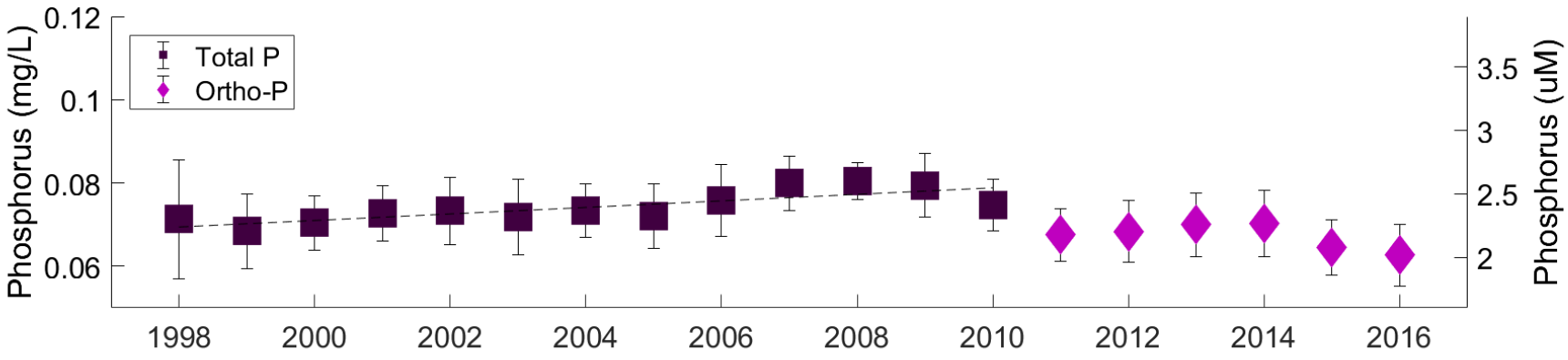
Deep Nutrients in Offshore Sites



Deep (> 150-m) Annual Average





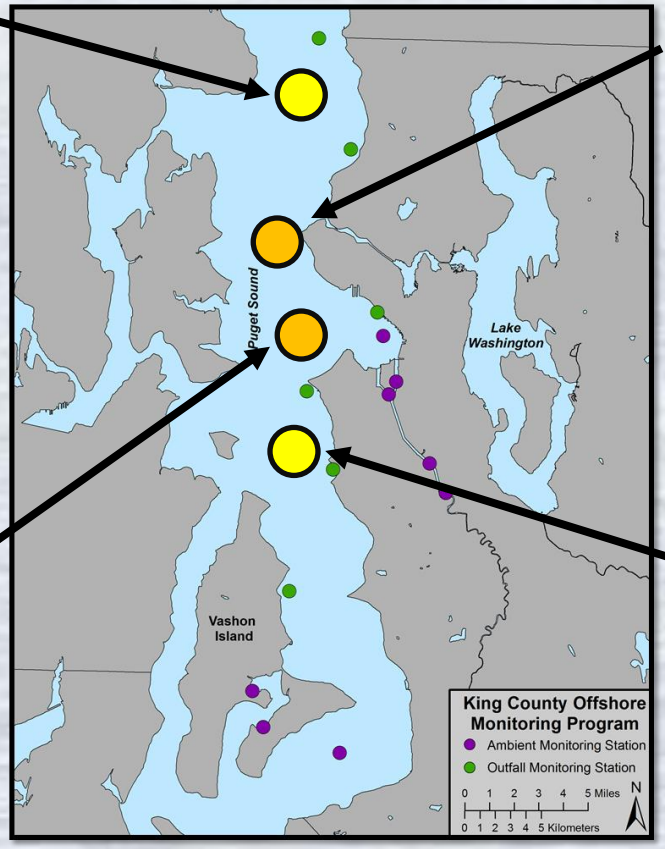


How Do Sites Compare?

- No significant differences in phosphorus or silica concentrations or trends between sites.

Pt. Jefferson

West Pt. Outfall



South Plant Outfall

Mid - Fauntleroy

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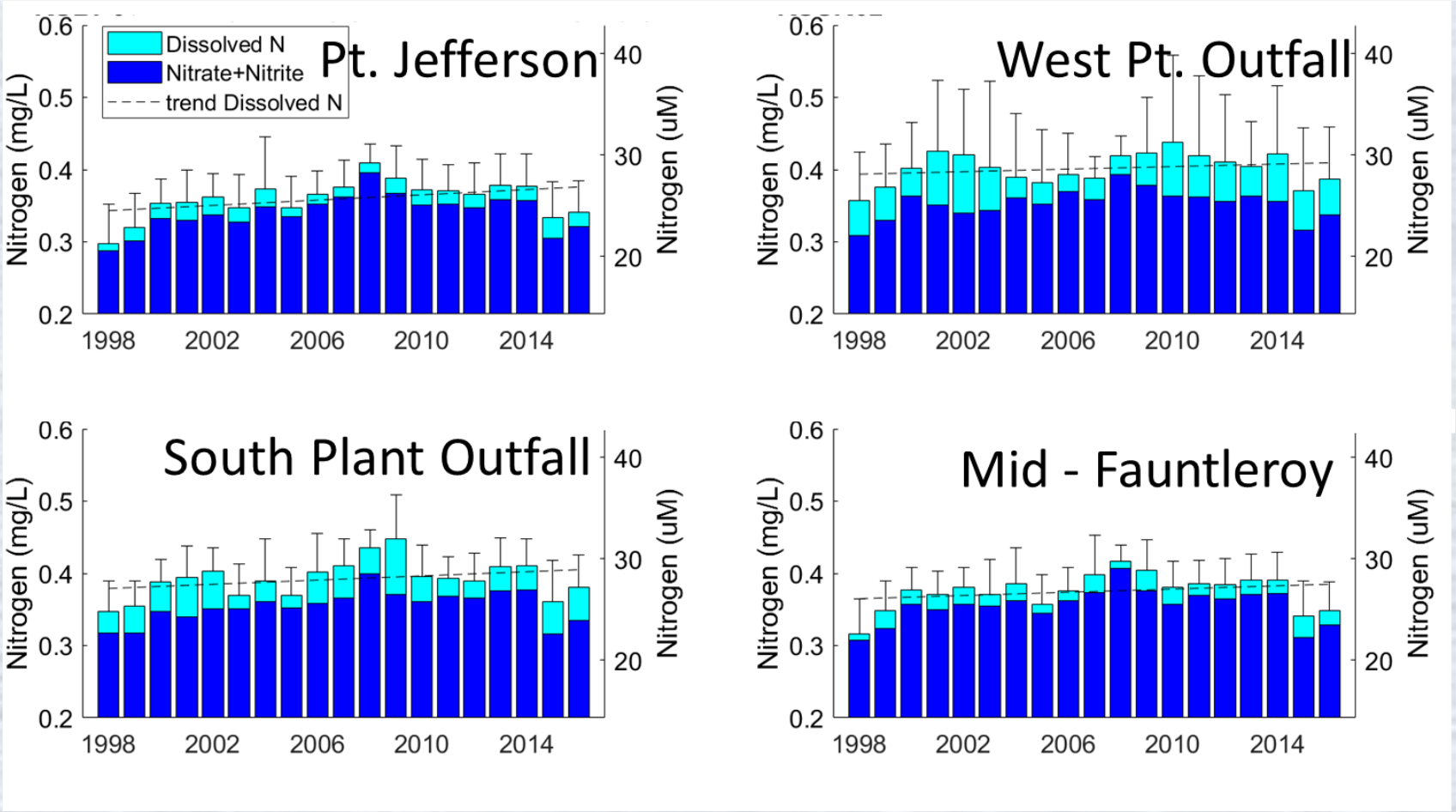
How Do Sites Compare?

- No significant differences in nitrate+nitrite concentrations or trends between sites.
- Higher levels of ammonia observed at outfall sites (shown by light blue); however, no significant difference in trends between sites over the 20-year record.



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Preliminary Trend Analysis

- Non-parametric trend test by month and depth (Mann-Kendall - Seasonal)

- Only use sites and depths with > 17 years of data
  (*exception: Total Phosphorus through 2010 only)

- Nutrients, Nutrient ratios, Chlorophyll-a and deep Dissolved Oxygen

Legend

% of Sites Showing a Significant Trend ($p < 0.1$)

≤ 25%	↔	↔
26 - 50%	↔	↔
51 - 75%	↗	↘
> 75%	↑	↓

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Similar trend for **all** nutrients over this period of record suggests driver from watershed/ocean balance

Number Sites	Depth Bin (meters)	Dissolved Inorg. Nitrogen (DIN)	Silica	Total Phosphorus*	Silica:DIN Ratio	DIN:TP Ratio*	Chlorophyll-a
9	1	↗	↔	↑	↔	↔	↔
9	15	↗	↑	↑	↔	↔	↔
8	25	↔	↑	↑	↔	↔	↔
8	35	↑	↑	↑	↔	↔	↔
Est. Mean Slope =		0.0018 mg/L/yr	0.018 mg/L/yr	0.0007 mg/L/yr			
% of Mean Value =		(~0.5%)	(~0.6%)	(~1%)			
7	55	↑	↑	↗	↔	↔	↔
4	100	↔	↑	↗	↔	↔	↔
4	>150	↔	↔	NA	↔	NA	↔
Est. Mean Slope =		0.0029 mg/L/yr	0.016 mg/L/yr	0.0006 mg/L/yr			
% of Mean Value =		(~0.5 - 1%)	(~0.6%)	(~0.9%)			

Dissolved Oxygen

Legend

% of Sites Showing a Significant Trend ($p < 0.1$)

≤ 25%	↔	↔
26 - 50%	↔	↔
51 - 75%	↗	↘
> 75%	↑	↓

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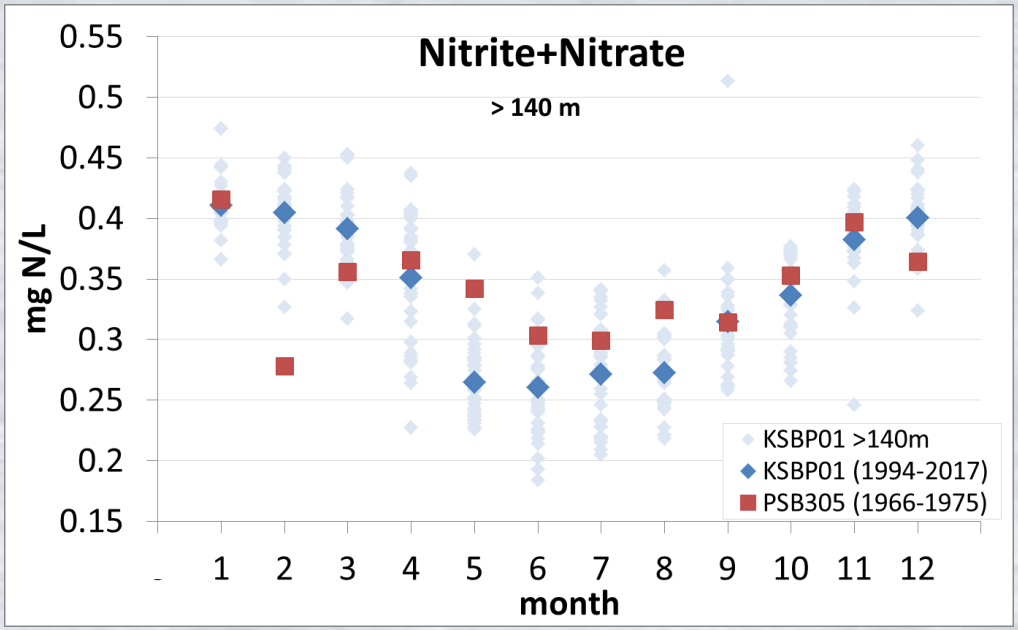
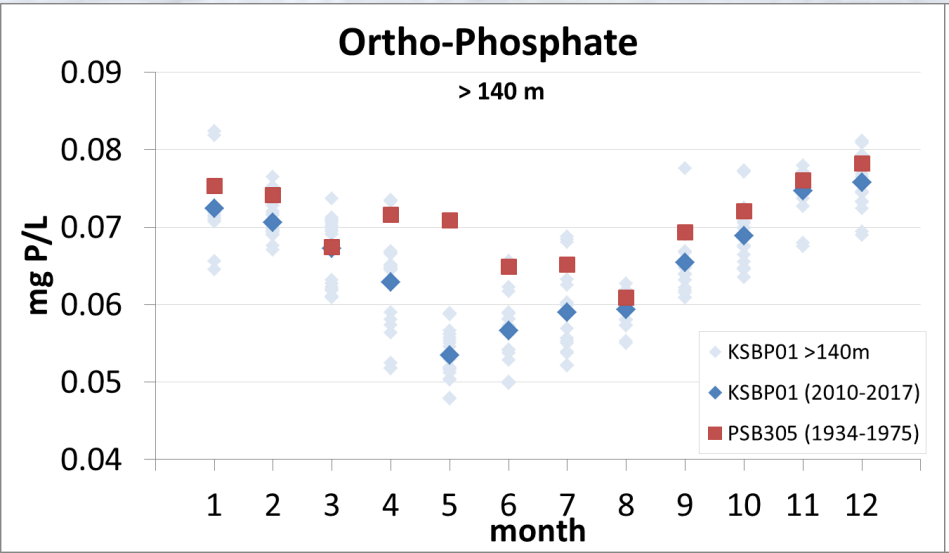
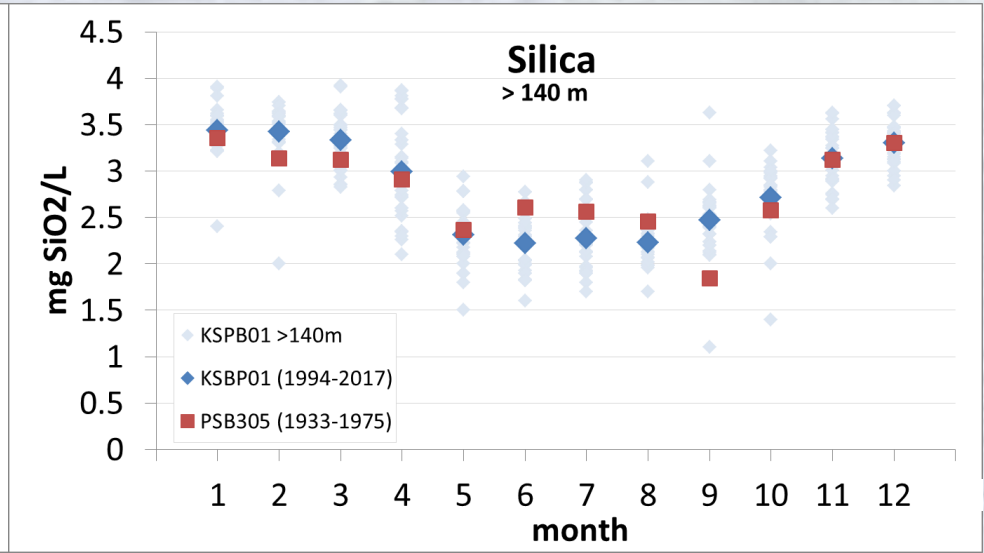
How does this compare to historical conditions? (Source: UW/Collias Atlas (1932 – 1975))

- Deep data (>140-m) collected from similar site near Pt. Jefferson from 1932 – present
- In general, recent nutrient data record falls within historical levels
- Further work needed to understand long-term trends







What are Mechanisms for Patterns in the Central Basin?

Weather/ Climate

River Discharge Ocean Upwelling

Water Column Stability

Phytoplankton

Nutrients

So what? - Impacts on the base of the food web

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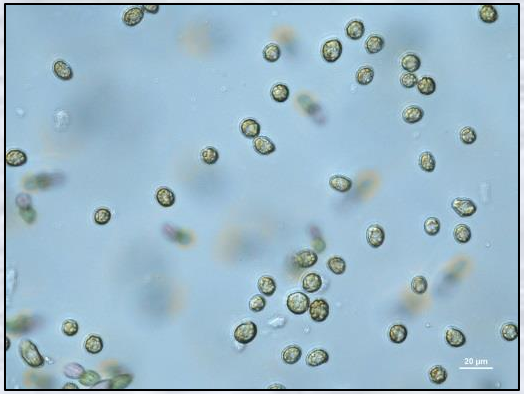
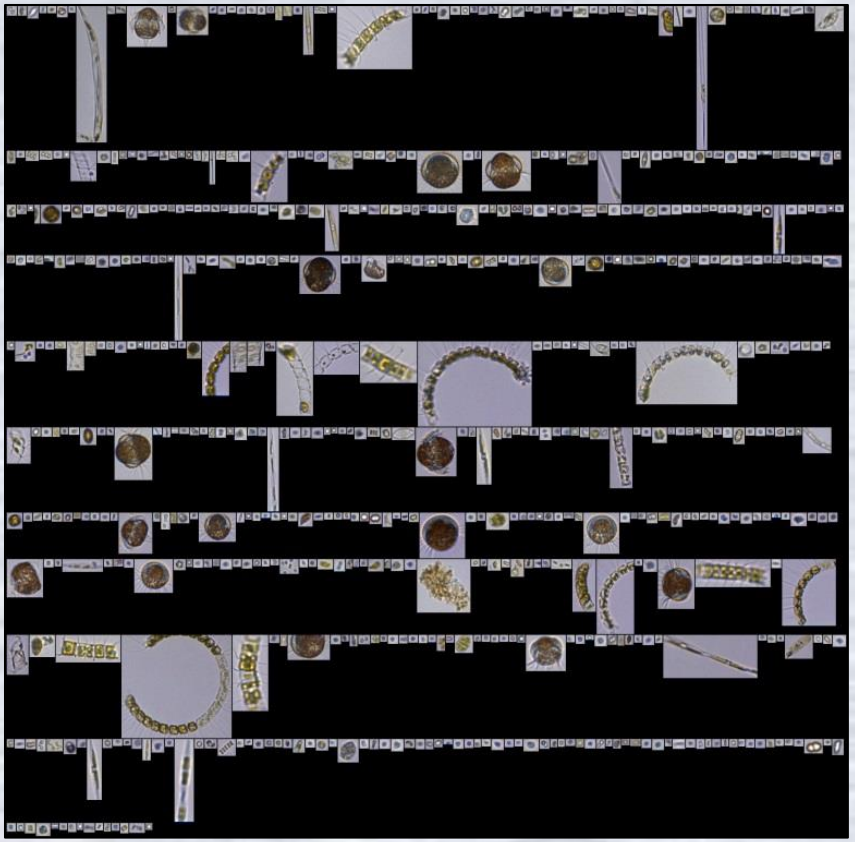
Phytoplankton Dynamics

2008-2016

- Typically 3-4 major peaks
- Timing is connected with weather/climate patterns





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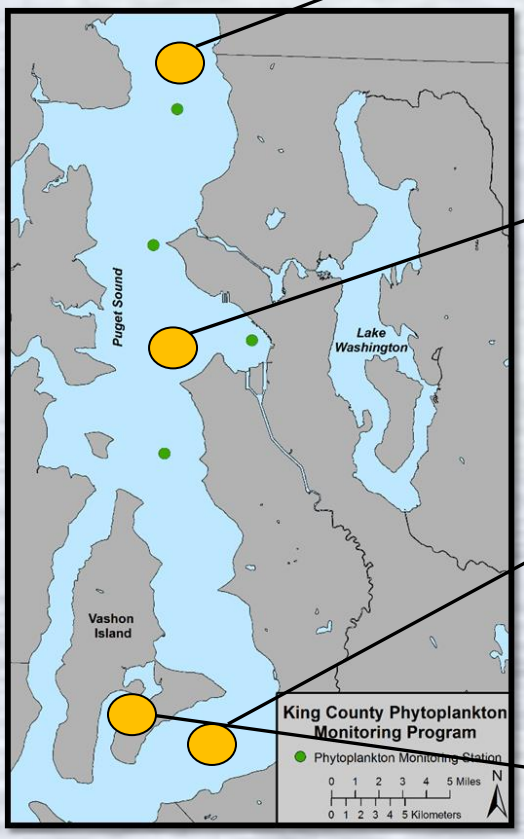
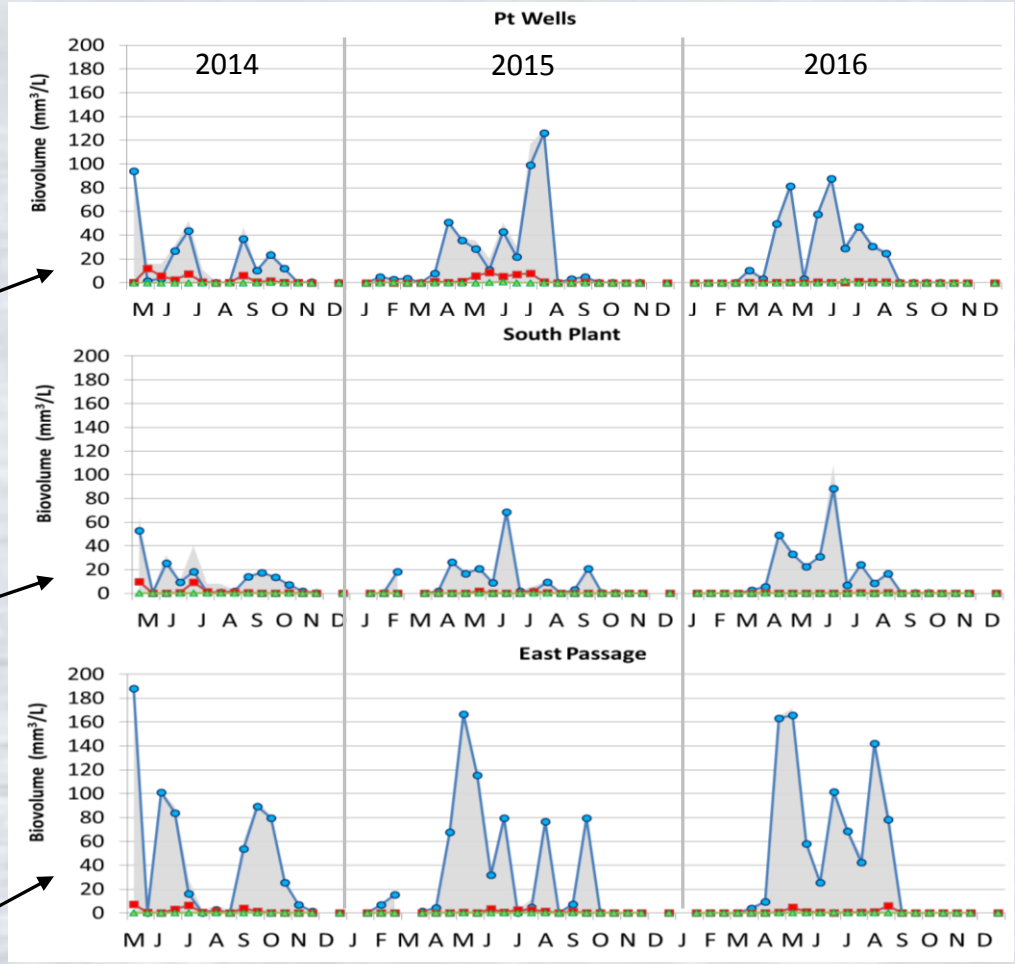
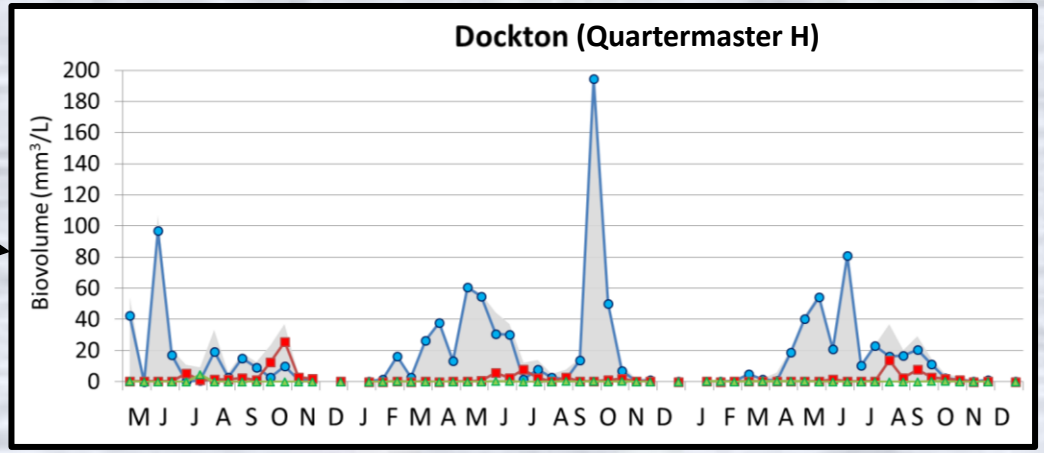
Major Taxa Pattern

Total Biovolume
Diatoms
Dinoflagellates
Other Phyto







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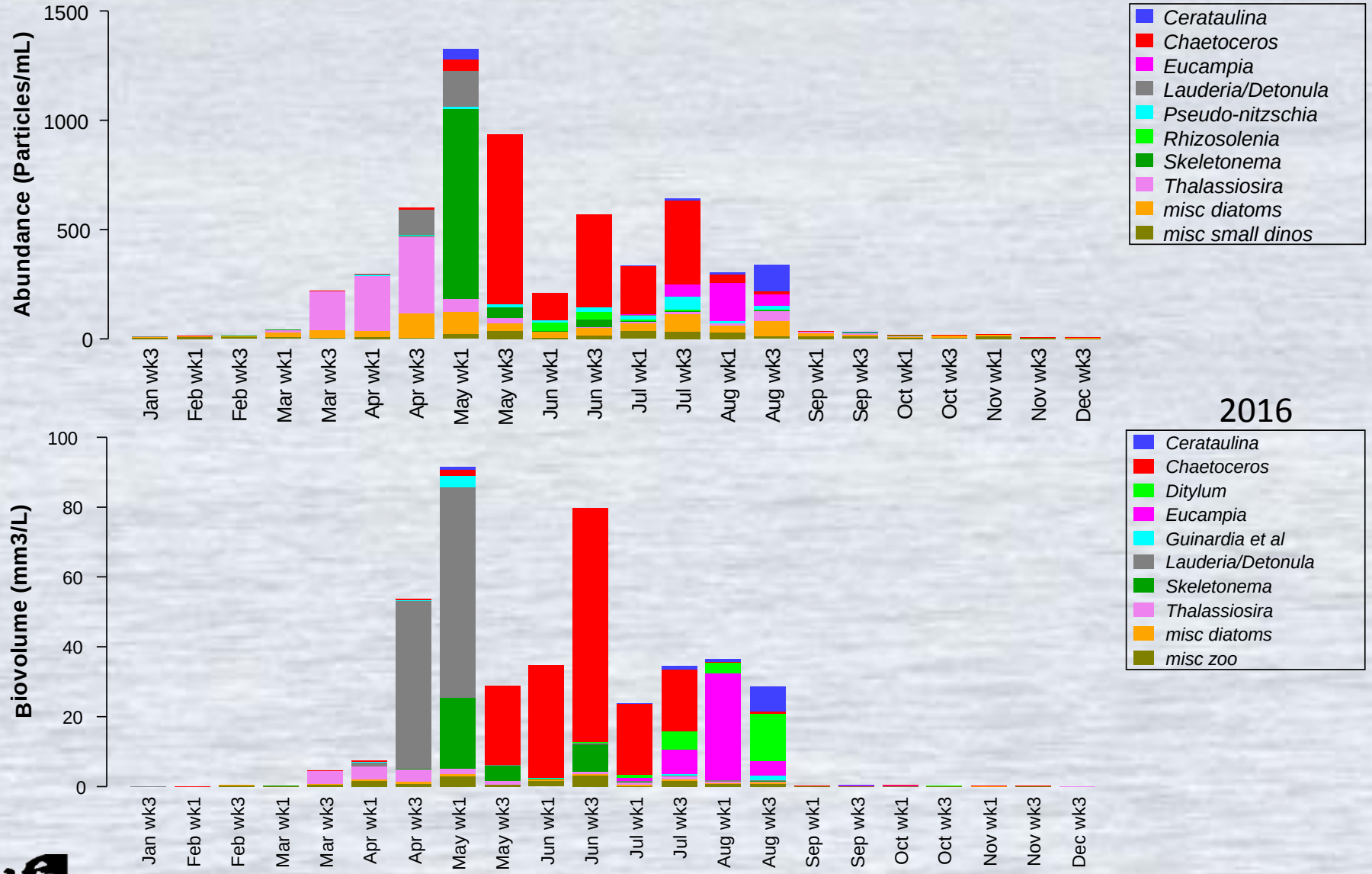
10 Main Taxonomic Categories

(9 categories are diatoms)



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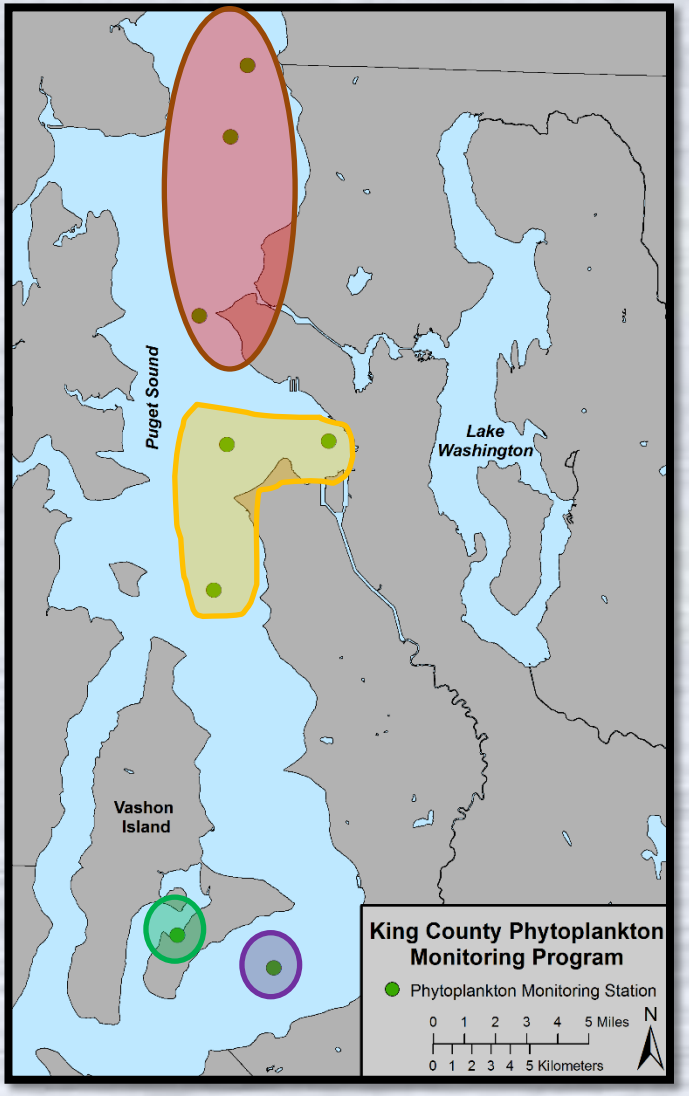
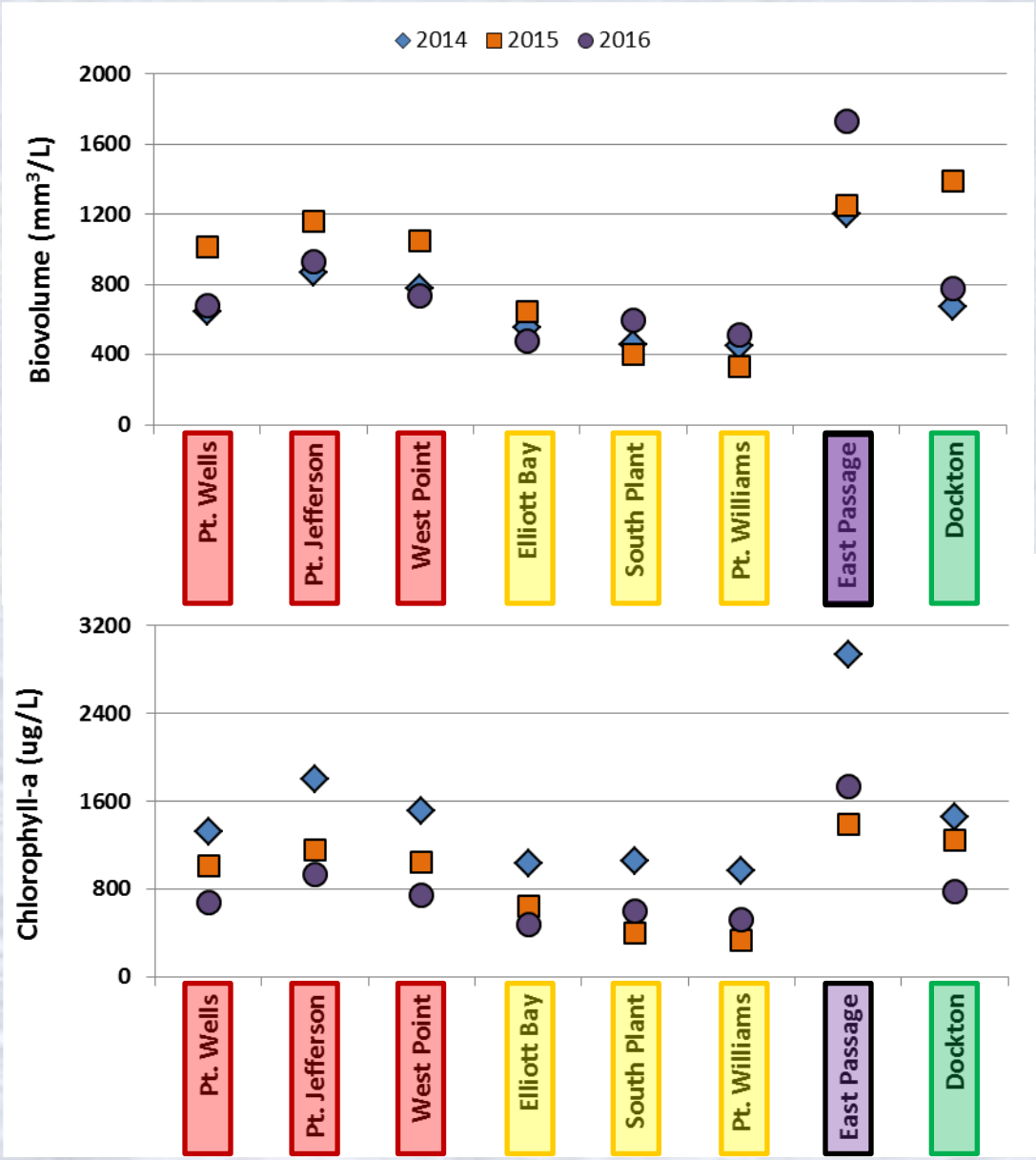
Distinct Geographic Differences





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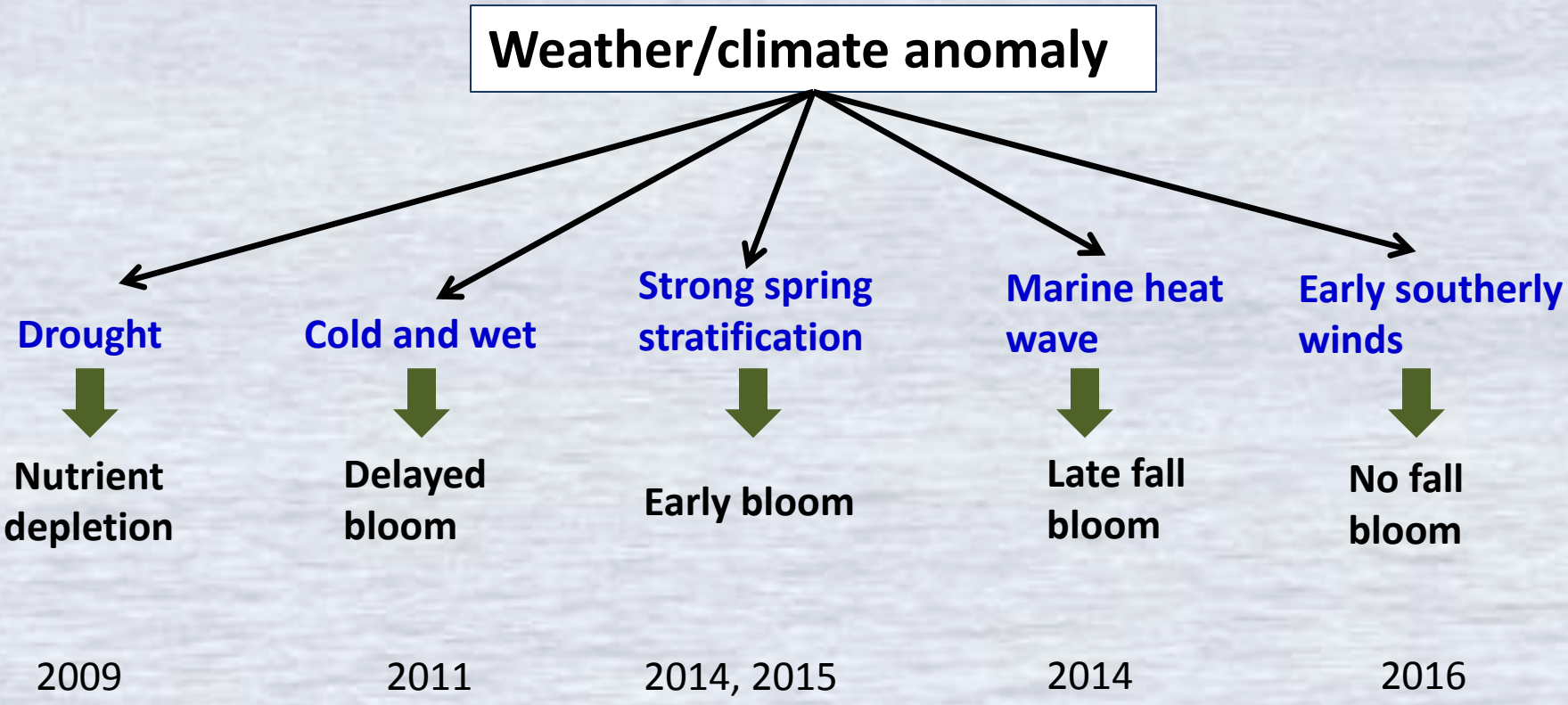
Phytoplankton/Physical Relationships



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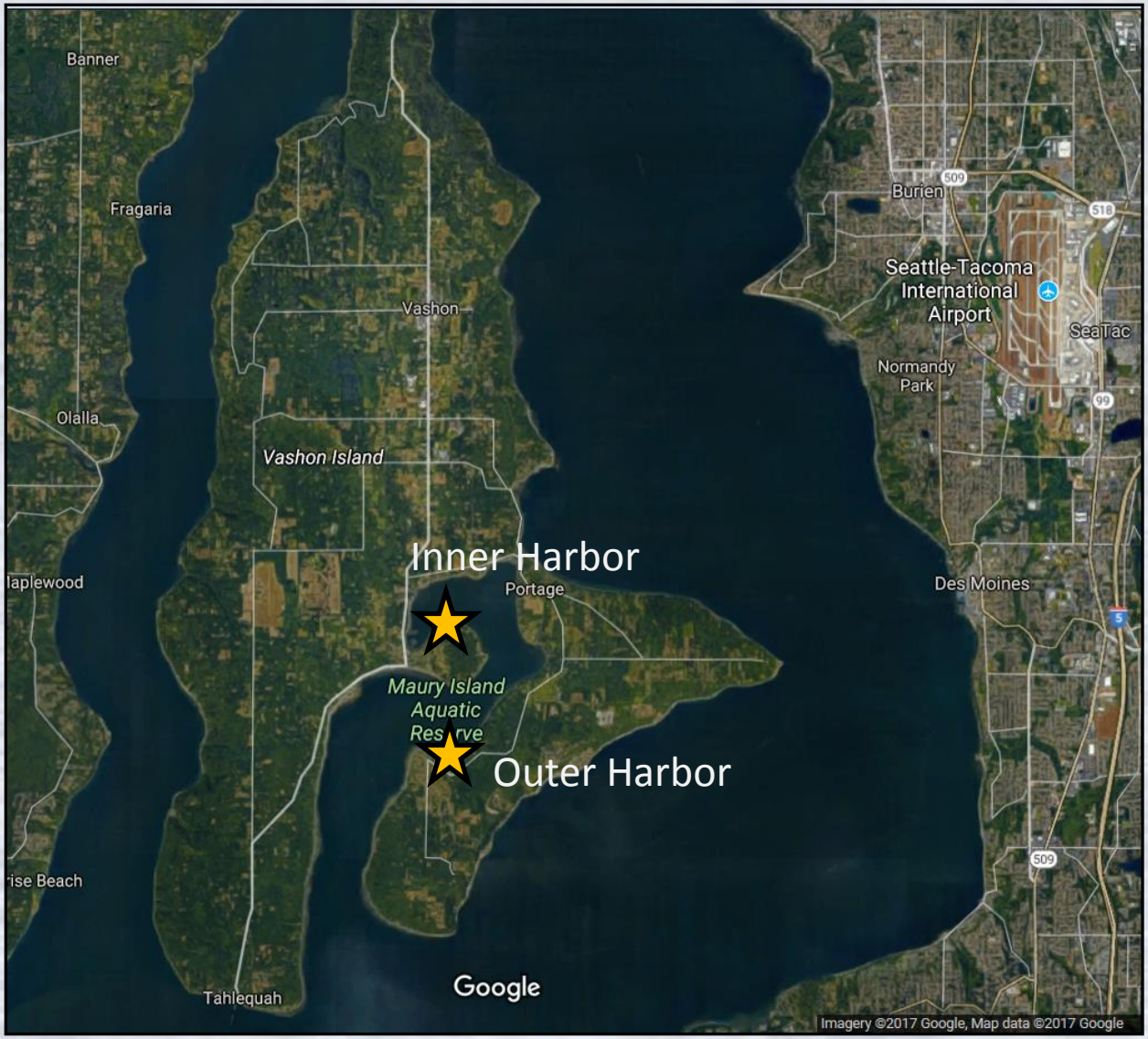
Quartermaster Harbor Sampling



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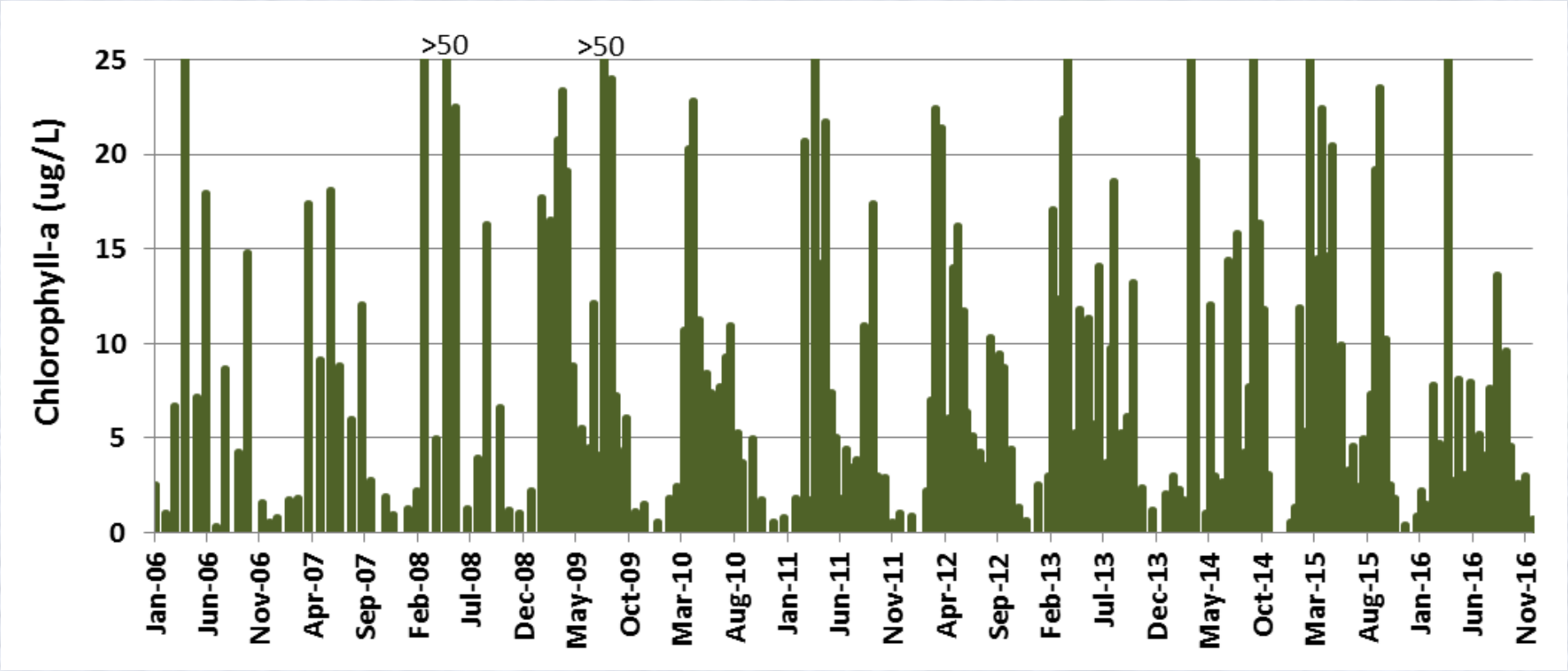
Quartermaster Phytoplankton Season

Outer Harbor



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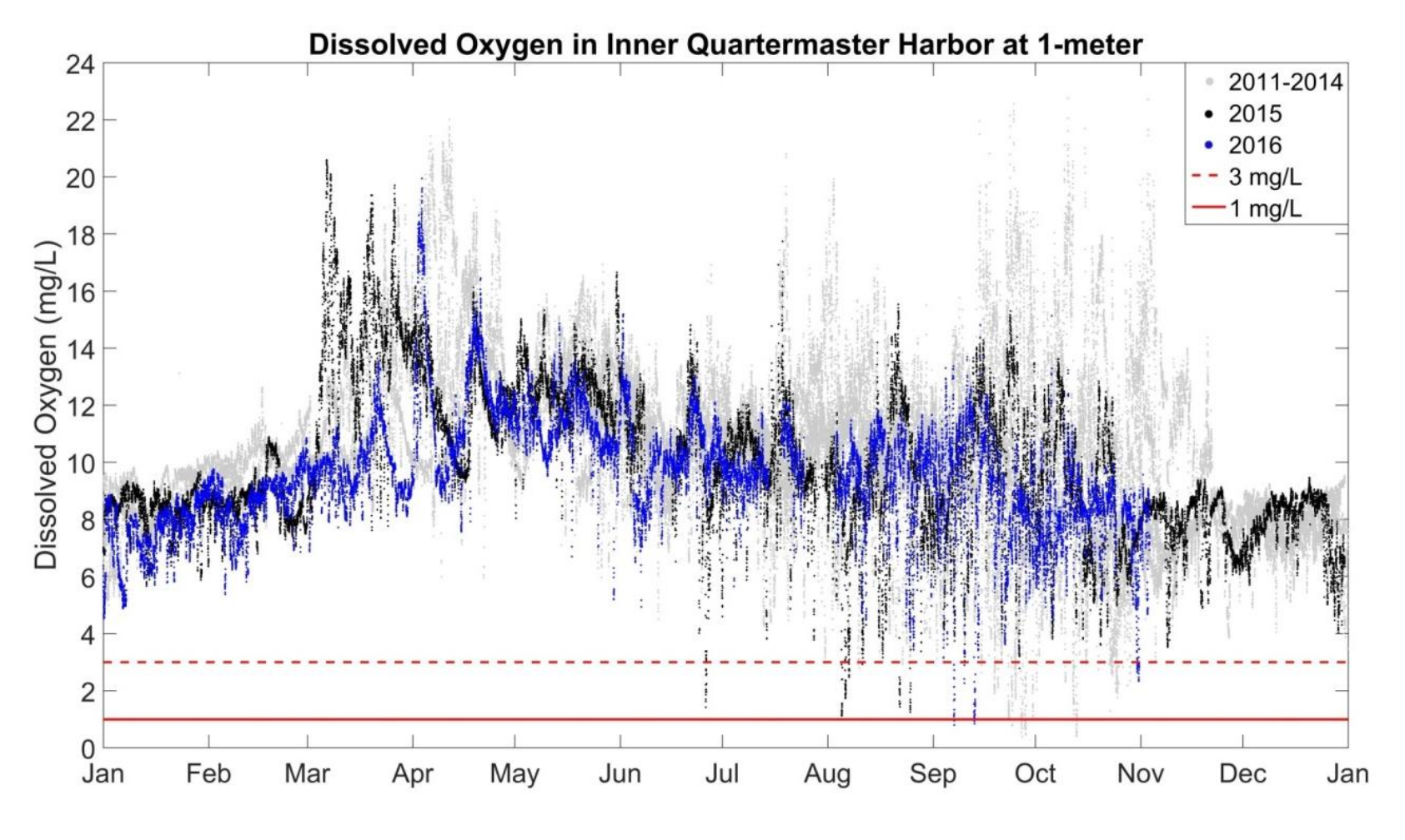
Quartermaster Dissolved Oxygen

Inner Harbor



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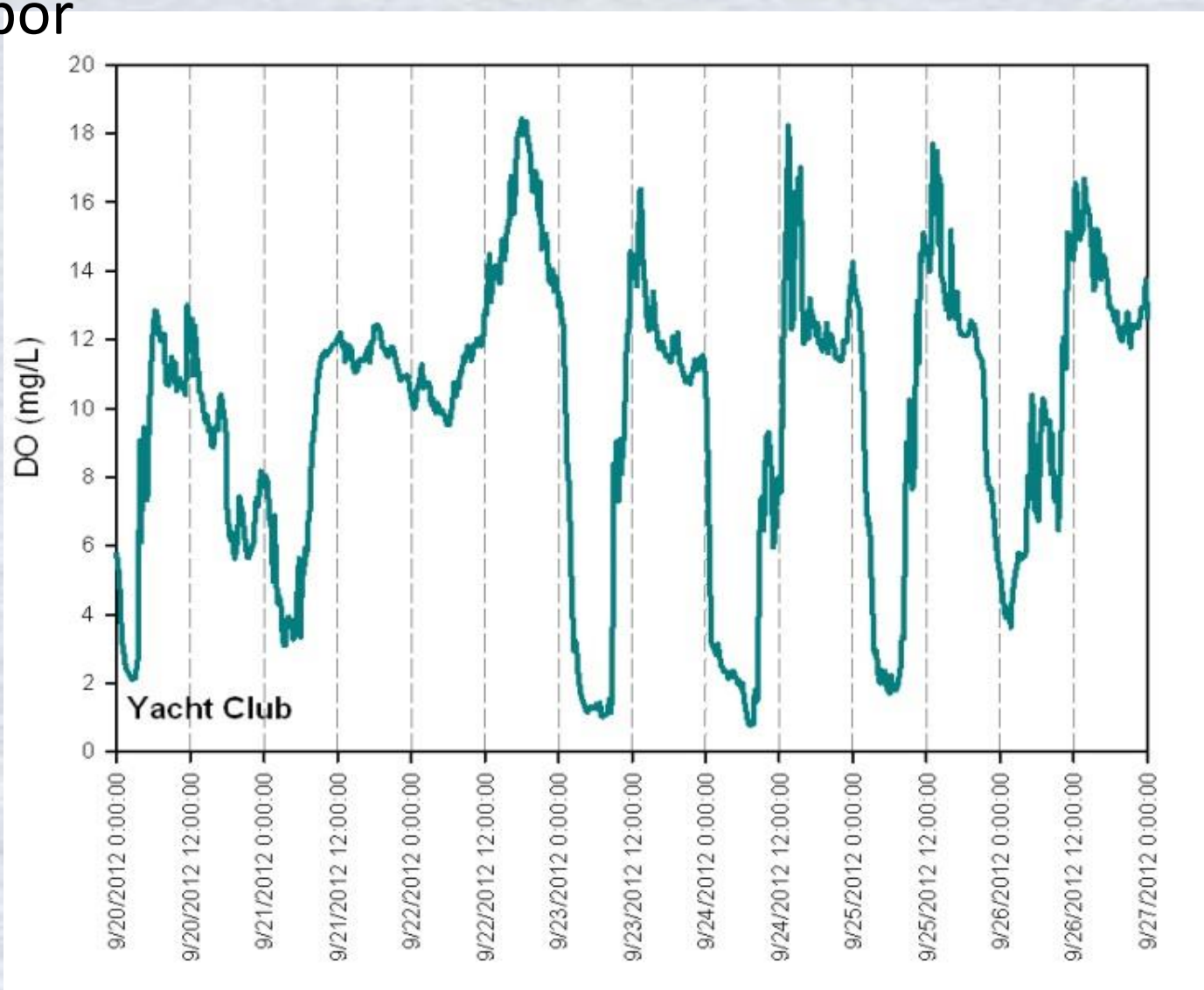
Quartermaster DO Rollercoaster

Inner Harbor



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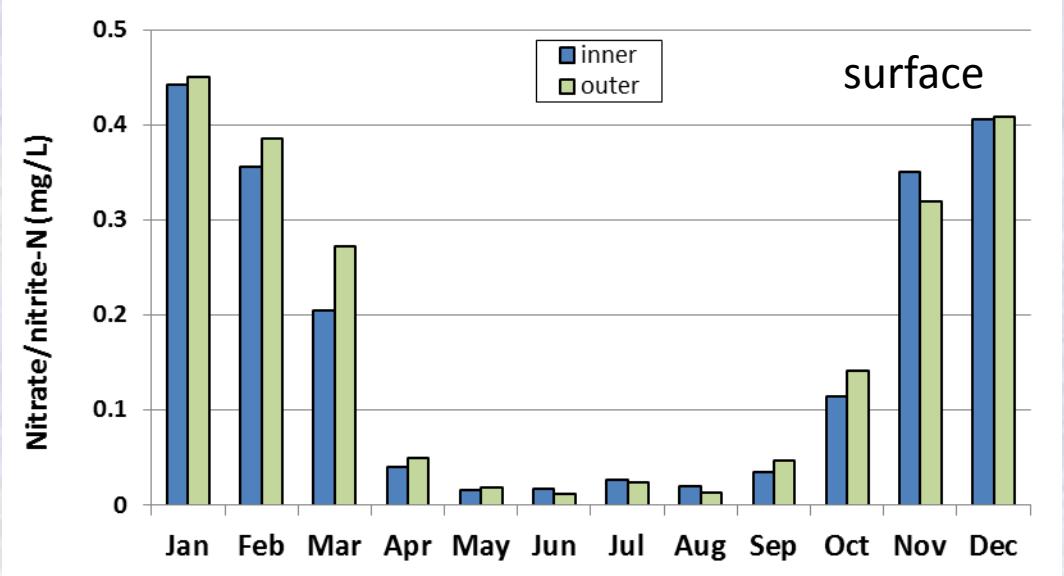
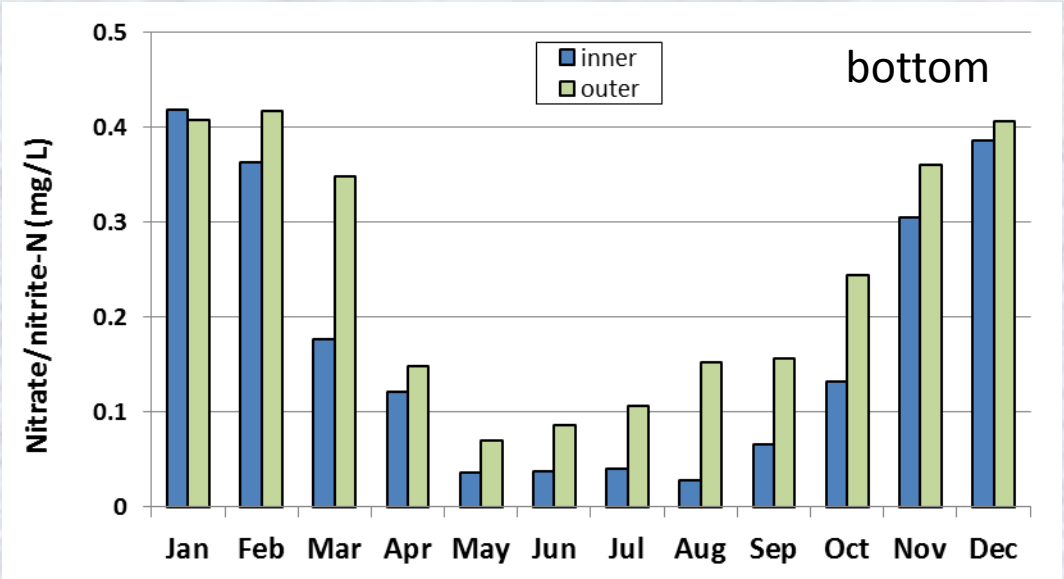
Quartermaster: Nitrate/Nitrite

- Monthly averages 2006-2016
- Inner harbor often nitrate limited
- No increasing nutrient trend





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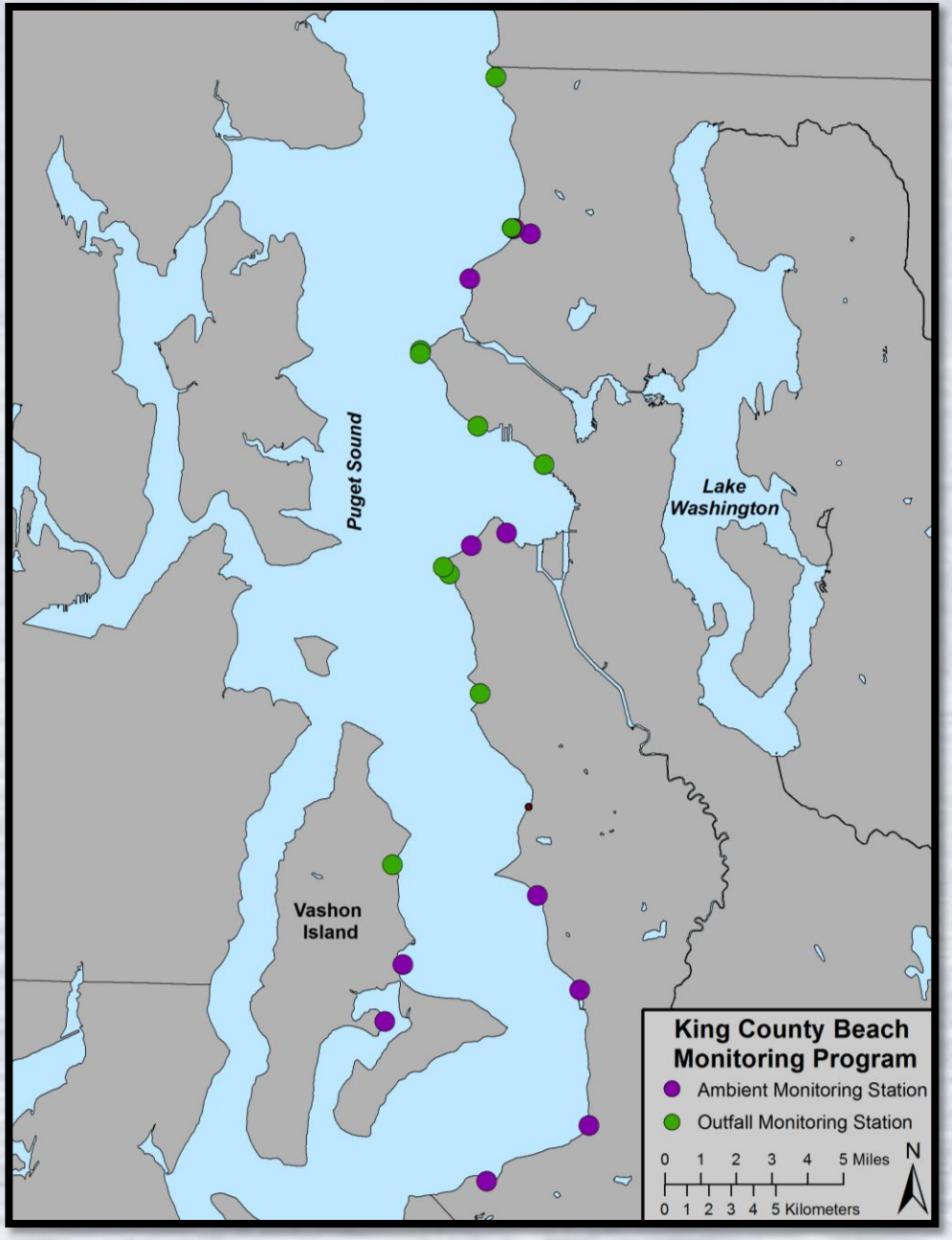
Beach Sites



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Beach Nutrients

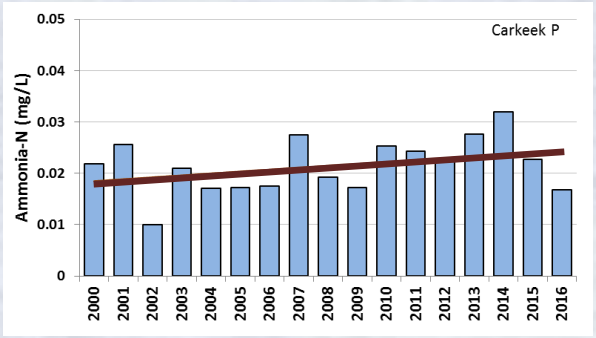
- Location, location, location….highly variable

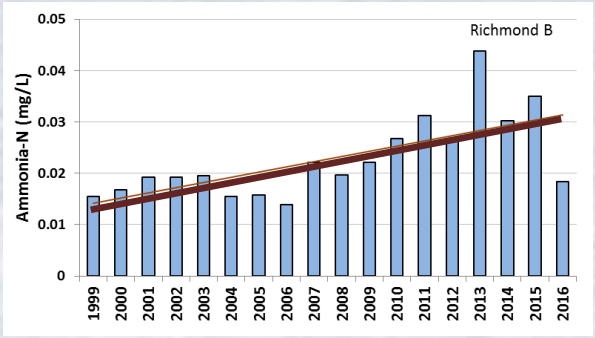
- Pattern is generally the same, differences seen in sites near a freshwater output and Quartermaster Harbor

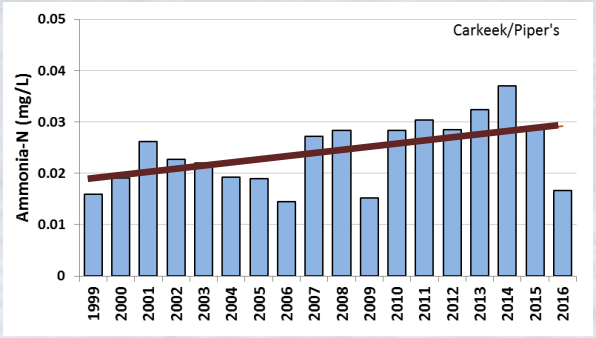
- No increasing trend for most nutrients at most sites. Do see an increase in ammonia at some sites. Need to explore role macroalgae and benthic diatoms play in beach nutrient dynamics.

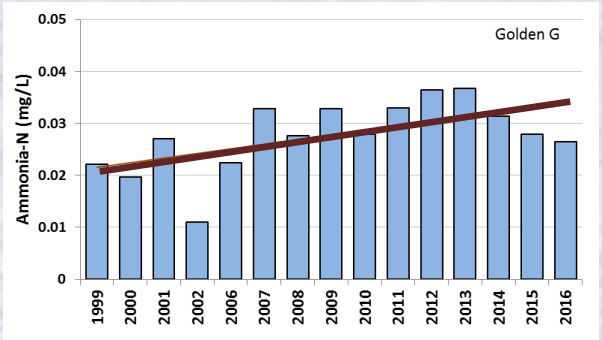
- Similar seasonal pattern to offshore, with summer nutrient decrease from algae uptake

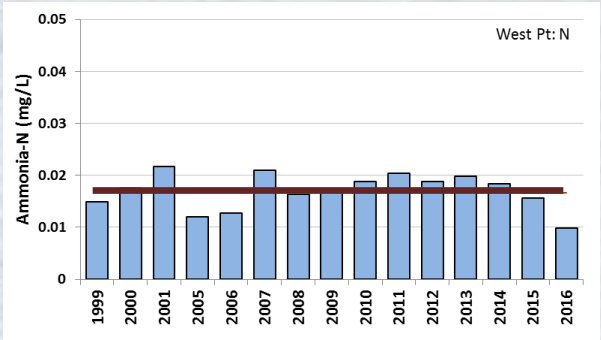
Beach Ammonia

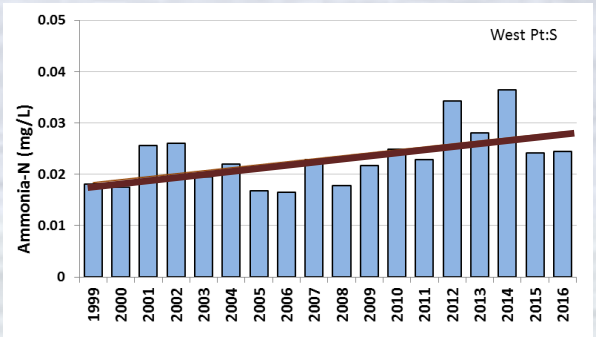


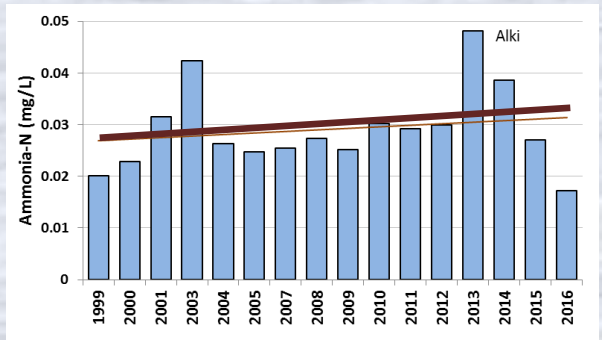


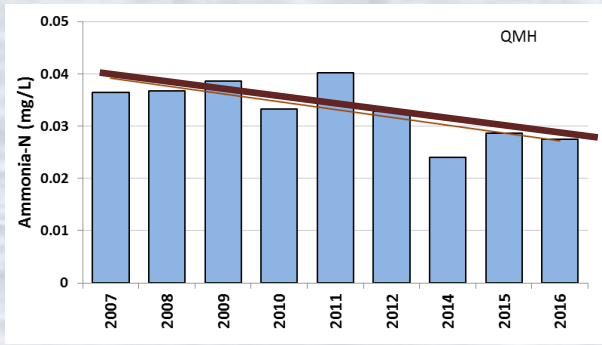


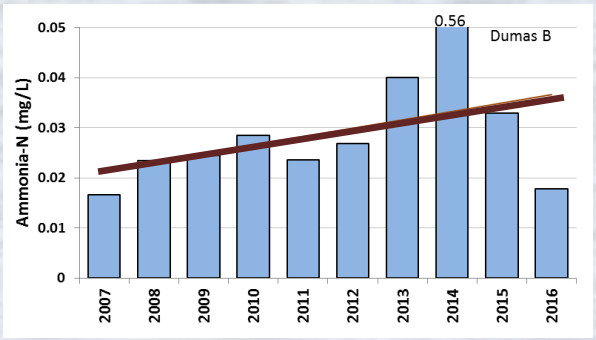












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Summary Points

- Some increasing trends at offshore sites for all nutrients
- No trend in deep dissolved oxygen
- No clear trends for beach nutrients
  - Exception = Ammonia and at sites near freshwater source
- Phytoplankton = drivers of nutrient levels at the surface
- Phytoplankton populations and dynamics vary significantly from year to year in relationship to weather/climate patterns and the environment

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Thank you!

Contributors:

- King County Environmental Lab staff for field sampling and lab analysis
- Wendy Eash-Loucks & Tim Clark: Water Quality & Quantity Group
- Gabriela Hannach & Lyndsey Swanson: King County Environmental Lab phytoplankton analysis