How did a large-scale climate anomaly impact phytoplankton blooms in Puget Sound in 2015?

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Background

What can we learn from large-scale climate anomalies?

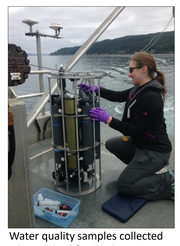
The Washington State Department of Ecology's Marine Waters Program has routinely monitored water quality throughout Puget Sound since 1973. Establishing historic baselines at long-term monitoring stations allows us to add context to spatial and temporal trends seen in marine water quality.

Water quality data are collected monthly via floatplane.

In 2015, we observed changes in marine water quality due to the large-scale climate anomaly "the Blob"—a mass of warm water that entered Puget Sound in the fall of 2014. In conjunction with the Blob, higher-than-normal air temperatures altered patterns of river discharge in 2015, changing water column stratification and salinity. Changes to hydrological patterns in Puget Sound have the ability to influence nutrient levels and water column stratification, indirectly affecting the timing and amplitude of phytoplankton blooms.

By comparing 2015 marine water quality data to baseline conditions (1999–2008), this study explores how the following played a role in altering the timing and magnitude of phytoplankton blooms in 2015:

1) The physical environment
2) River discharge
3) Nutrient cycling



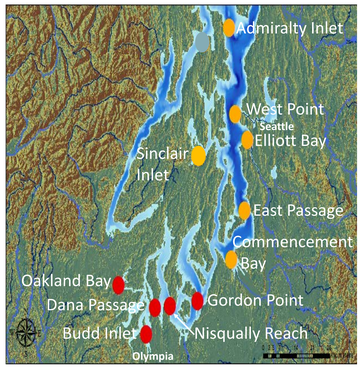
Water quality samples collected aboard the R/V *Skookum*.

Why focus on phytoplankton?

- Ecosystem function is reliant on phytoplankton production transferring energy to higher trophic levels.
- Climate impacts modify bloom timing, amplitude, and duration, resulting in altered energy flow to higher trophic levels.

Methods

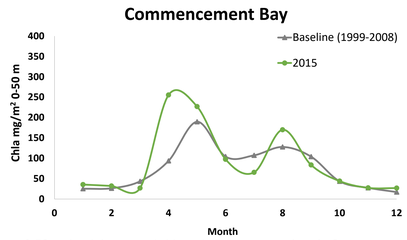
- Long-term monitoring stations are visited monthly via floatplane and boat.
- Standard operating procedures are followed for seawater sampling, analysis and data quality assurance.
- Data collected from Central and South Sound in 2015 were compared to an established historic baseline (1999–2008).
- Heat maps were generated to show anomalies in 2015 water quality data.



Central (orange) and South Sound (red) long term monitoring stations. Map by Mya Keyzers

Regional Differences in Phytoplankton Blooms in 2015

Central Sound



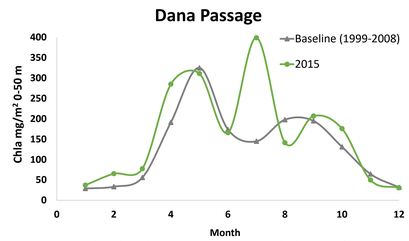
0-50 m depth integrated chlorophyll a concentrations in Commencement Bay

- Spring Bloom: Earlier timing, higher amplitude
- Summer Bloom: Expected timing, higher amplitude

Station	Month 1	2	3	4	5	6	7	8	9	10	11	12
Admiralty Inlet												
West Point												
Sinclair Inlet												
Elliott Bay												
East Passage												
Commencement Bay												

2015 Central Sound chlorophyll concentrations relative to baseline levels

South Sound



0-50 m depth integrated chlorophyll a concentrations in Dana Passage

- Spring Bloom: Earlier timing, expected amplitude
- Summer Bloom: Earlier timing, higher amplitude

Station	Month 1	2	3	4	5	6	7	8	9	10	11	12
Gordon Point												
Nisqually Reach												
Dana Passage												
Budd Inlet												
Oakland Bay												

2015 South Sound chlorophyll concentrations relative to baseline levels

= Higher = Lower = Expected = No Data

Factors Influencing Phytoplankton Blooms

1. The Physical Environment

Central Sound

South Sound

Stratification

Station	Month 1	2	3	4	5	6	7	8	9	10	11	12
Admiralty Inlet												
West Point												
Sinclair Inlet												
Elliott Bay												
East Passage												
Commencement Bay												

Stratification levels were stronger than expected throughout the winter, followed by weaker stratification levels throughout the spring and summer months.

Station	Month 1	2	3	4	5	6	7	8	9	10	11	12
Gordon Point												
Nisqually Reach												
Dana Passage												
Budd Inlet												
Oakland Bay												

Stratification levels varied across all stations throughout 2015.

Salinity

Station	Month 1	2	3	4	5	6	7	8	9	10	11	12
Admiralty Inlet												
West Point												
Sinclair Inlet												
Elliott Bay												
East Passage												
Commencement Bay												

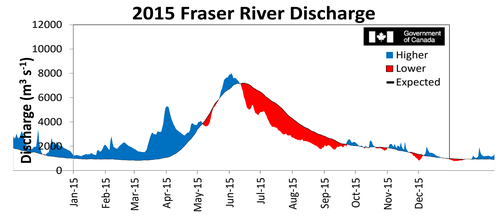
Relative to baseline levels, salinity was lower in the winter and spring and higher in the summer.

Station	Month 1	2	3	4	5	6	7	8	9	10	11	12
Gordon Point												
Nisqually Reach												
Dana Passage												
Budd Inlet												
Oakland Bay												

Relative to baseline levels, salinity was lower in the winter and higher in the summer and fall.

= Higher = Lower = Expected = No Data

2. River Flow



The Fraser River in Canada is the largest contributor of fresh water to the Salish Sea. Changes in the Fraser River discharge alter the later exchange of water flowing between Puget Sound and the Pacific Ocean. Phytoplankton blooms are indirectly affected by the river through changes in the the physical and chemical environment.

Winter/Spring

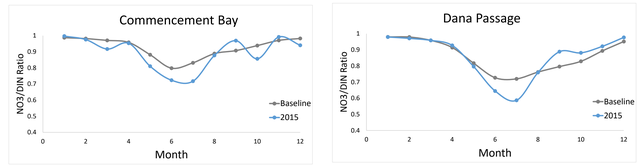
- Premature river discharge
- Stronger stratification levels in Central Sound → earlier spring bloom
- Lower levels of salinity in both regions

Summer

- Low river flows
- Weaker levels of stratification in Central Sound
- Higher levels of salinity in both regions

South Sound was less affected by stratification, likely due to tidal mixing.

3. Nutrient Cycling



In the summer months, higher amounts of reduced nitrogen (low nitrate/dissolved inorganic nitrogen ratio) were present in both Central and South Sound. This suggests that more nitrogen was being recycled in the water column compared to previous years.

Conclusions

- Large-scale climate anomalies provide useful information about how warming global and ocean temperatures will impact phytoplankton blooms in Puget Sound.
- Regions in Puget Sound may respond differently to future climate impacts.
- More research on lower-trophic-level food web dynamics is needed to understand how ecosystem functioning in Puget Sound is affected by changes in the timing and amplitude of phytoplankton blooms.

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