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Lake Whatcom Water Quality - Presentation to Bellingham City Council

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Lake Whatcom Water Quality

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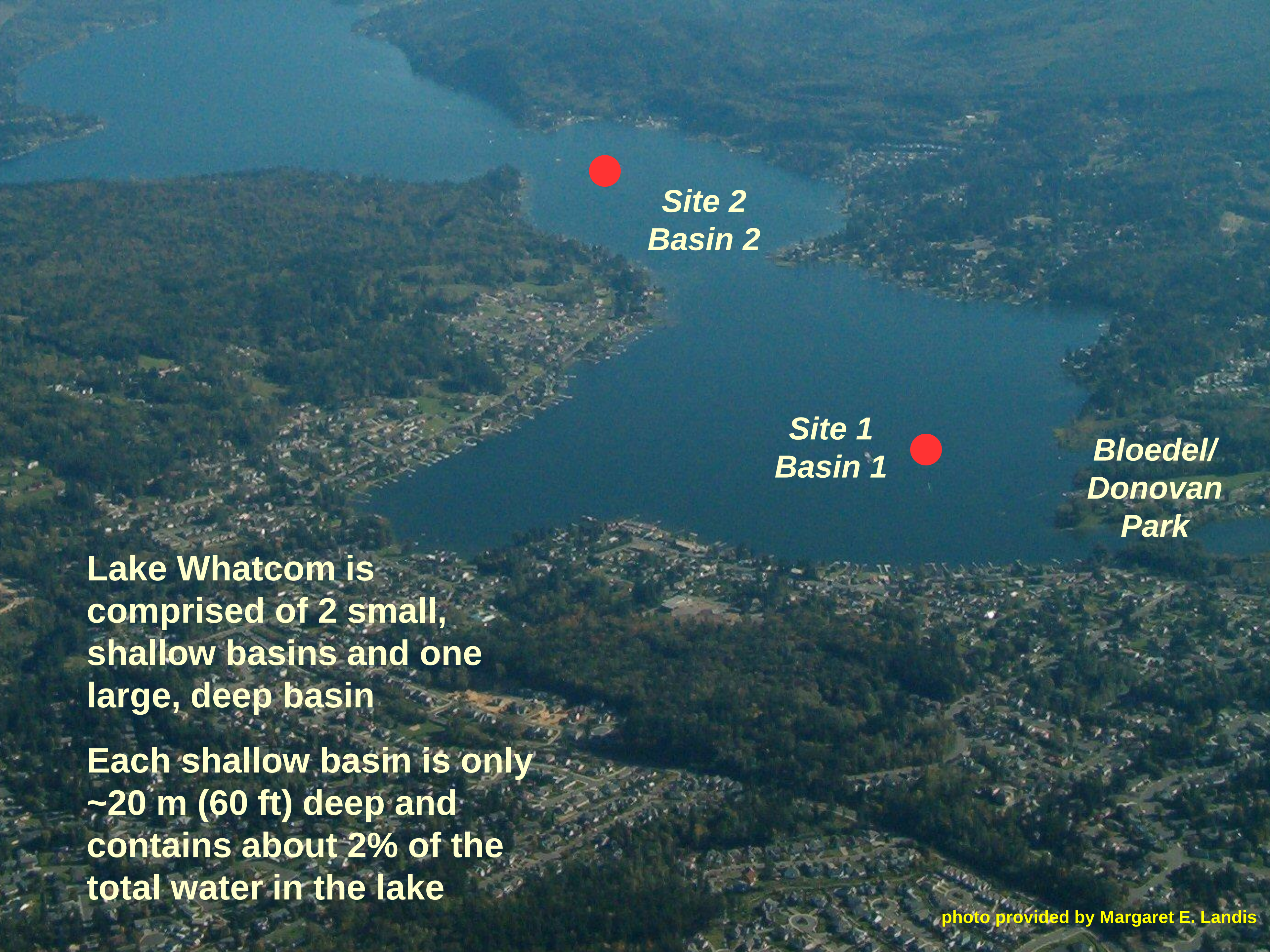
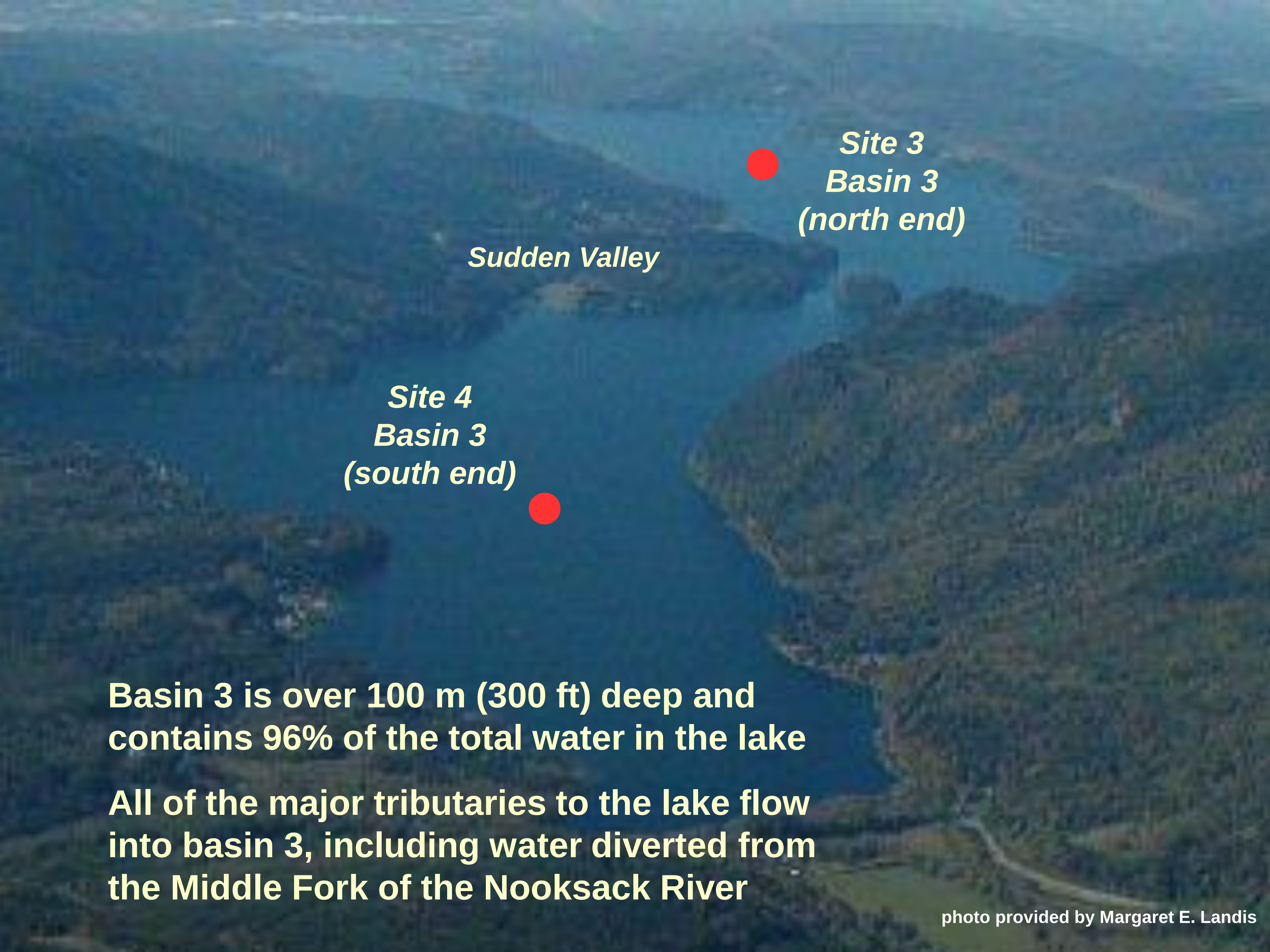
July 6, 2015



Lake Whatcom is comprised of 2 small, shallow basins and one large, deep basin

Each shallow basin is only ~20 m (60 ft) deep and contains about 2% of the total water in the lake


Site 3
Basin 3
(north end)
Sudden Valley
Site 4
Basin 3
(south end)
Basin 3 is over 100 m (300 ft) deep and contains 96% of the total water in the lake
All of the major tributaries to the lake flow into basin 3, including water diverted from the Middle Fork of the Nooksack River
photo provided by Margaret E. Landis

Lake Whatcom Monitoring Objectives

- Conduct long-term lake and stream monitoring
  - Emphasis on lake and storm event monitoring
    - Silver Beach Creek 2009-2012
    - Anderson, Austin, and Brannian Creeks 2013-2015
  - Tributaries in alternate years (annual 2016-2018)

- Collect stream hydrologic data
  - Annual hydrographs for Austin and Smith Creeks
  - Other tributaries monitored by USGS

Sampling Parameters

Lake, Tributaries, and Storm Event Sampling

Alkalinity	Conductivity	Dissolved oxygen
pH	Temperature	Nutrients (N/P)

Lake Only

Chlorophyll	Turbidity	Plankton
Secchi depth	T. organic carbon*	Hydrogen sulfide*

Tributaries and Storm Events Only

T. suspended solids

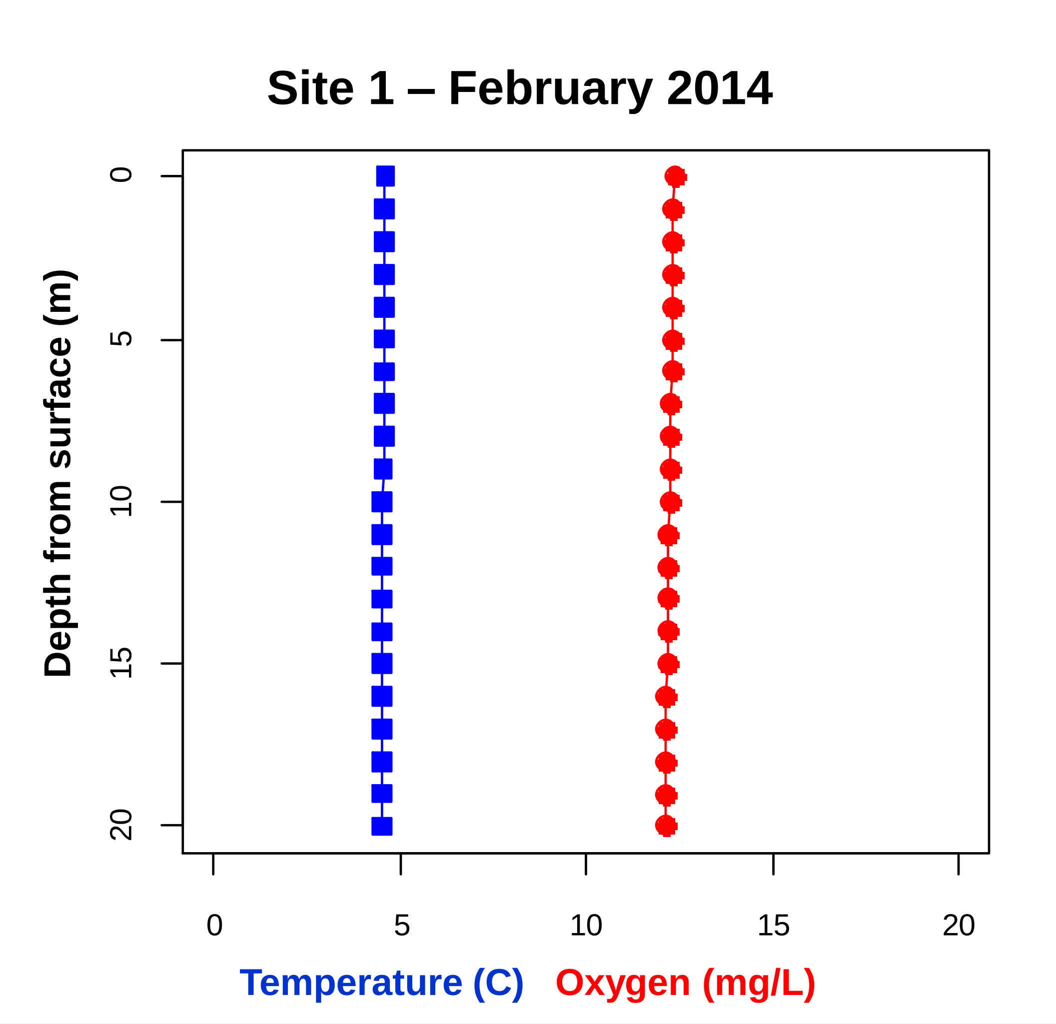
*infrequent sampling

Winter Water Quality in Lake Whatcom

Lake is cold and *unstratified*; water column mixes from surface to bottom … even basin 3 (100 m)

Temperature is nearly uniform from surface to bottom

Dissolved oxygen and most other compounds are nearly uniform from surface to bottom

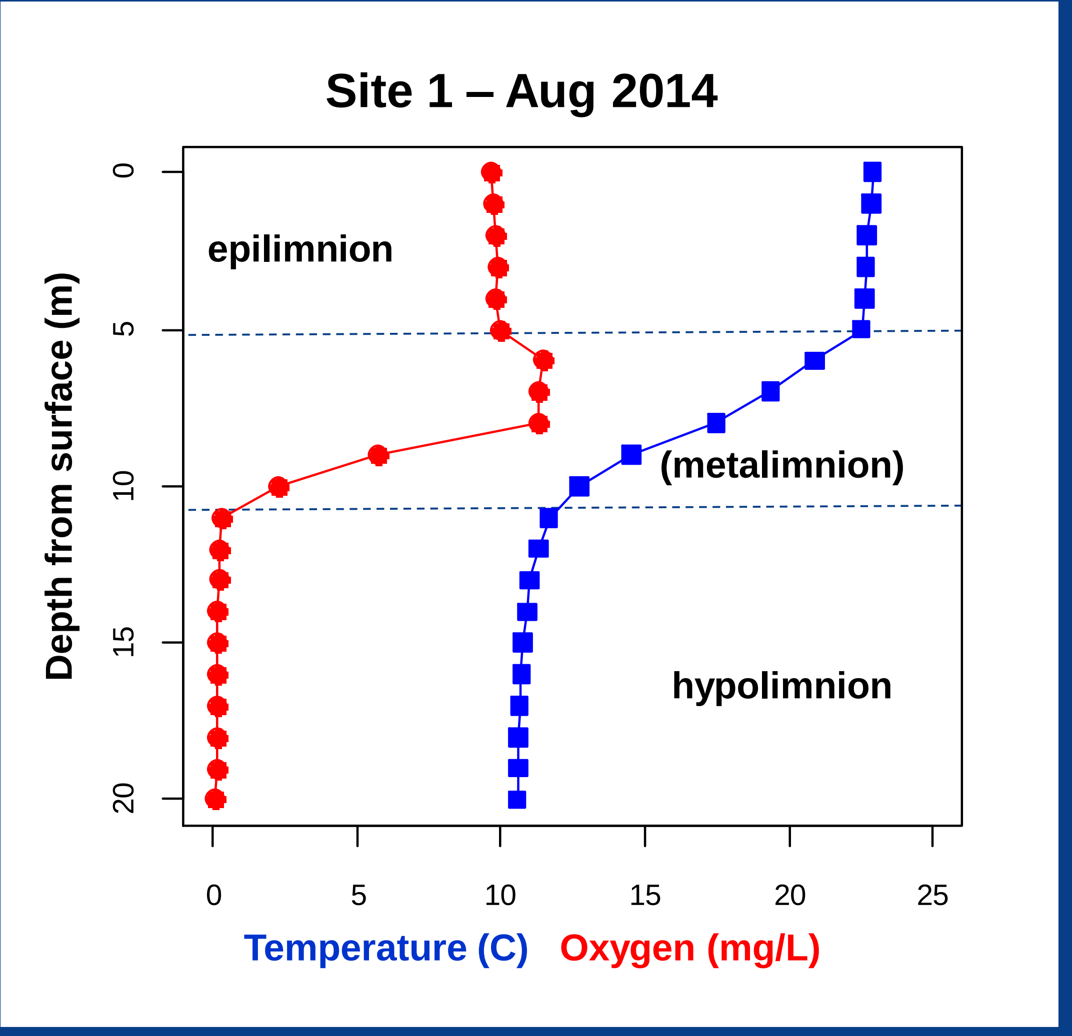


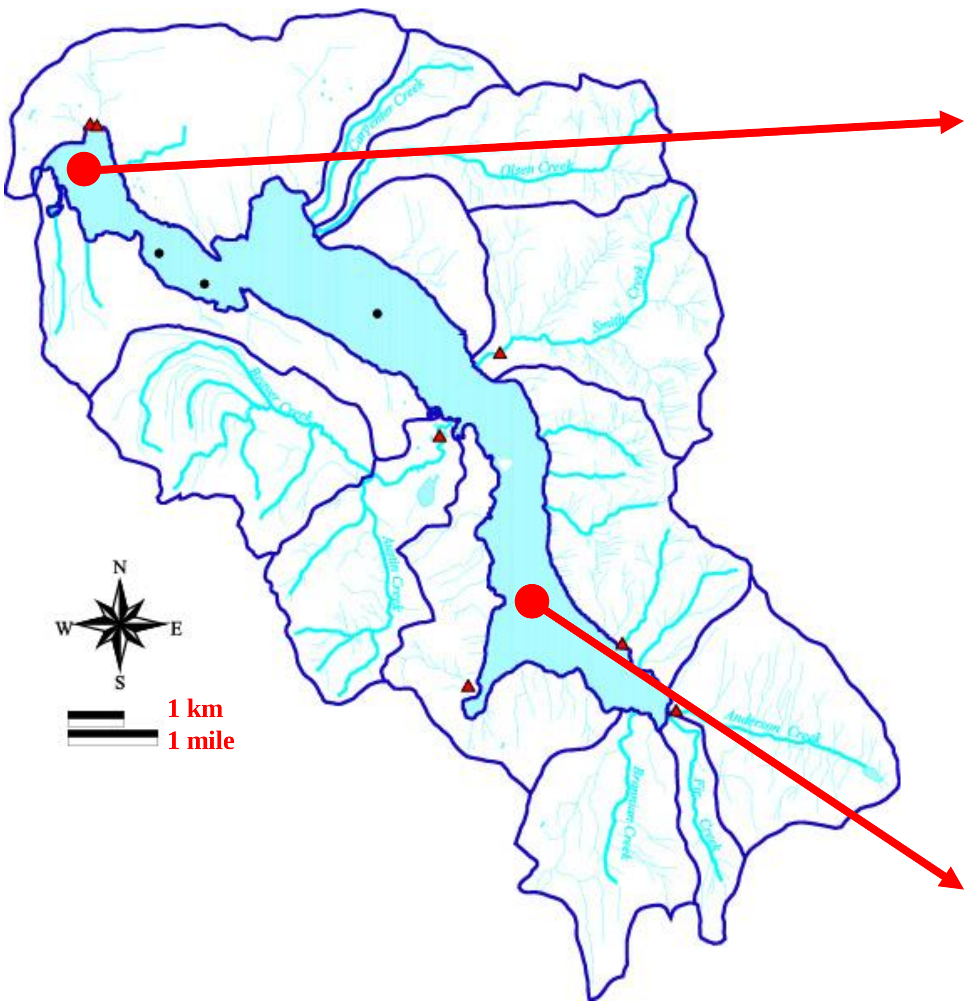
Summer Water Quality in Lake Whatcom

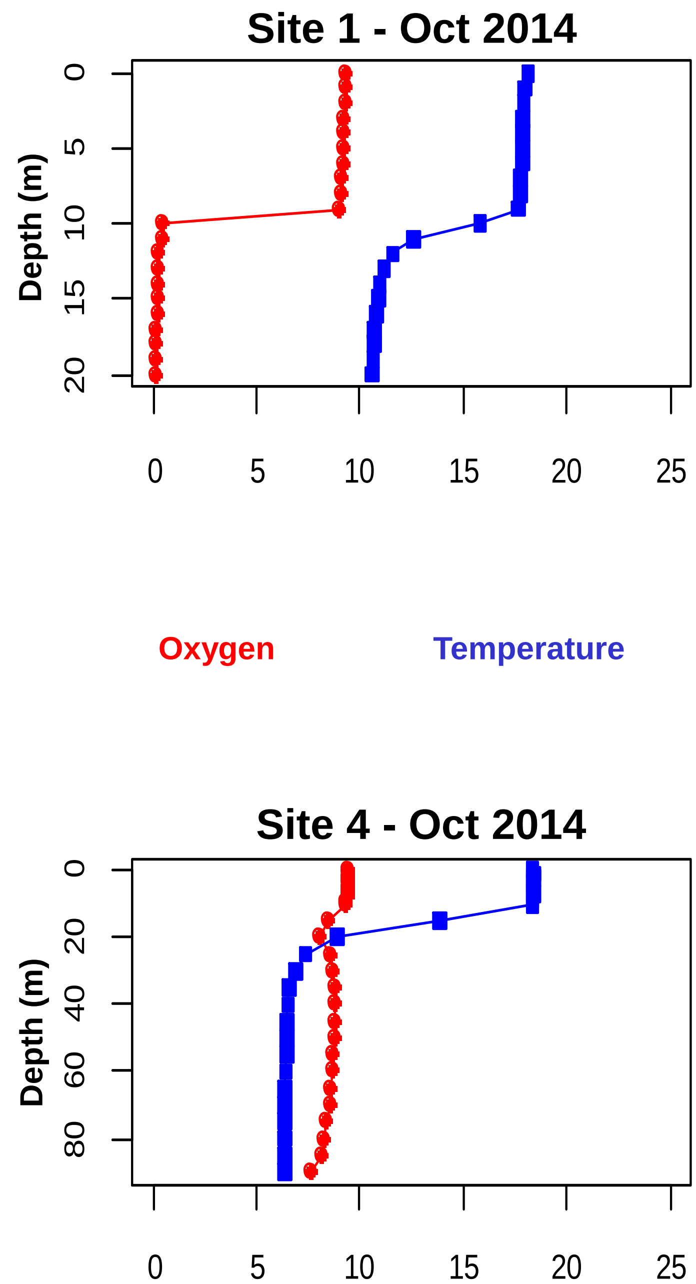
Lake becomes *stratified* into a warm surface layer (*epilimnion*) and cold bottom layer (*hypolimnion*)

Once stratified, wind can't mix the entire water column

In parts of the lake (Sites 1-2), oxygen is depleted in the hypolimnion as bacteria decompose organic matter (dead algae, leaf fragments, etc.)





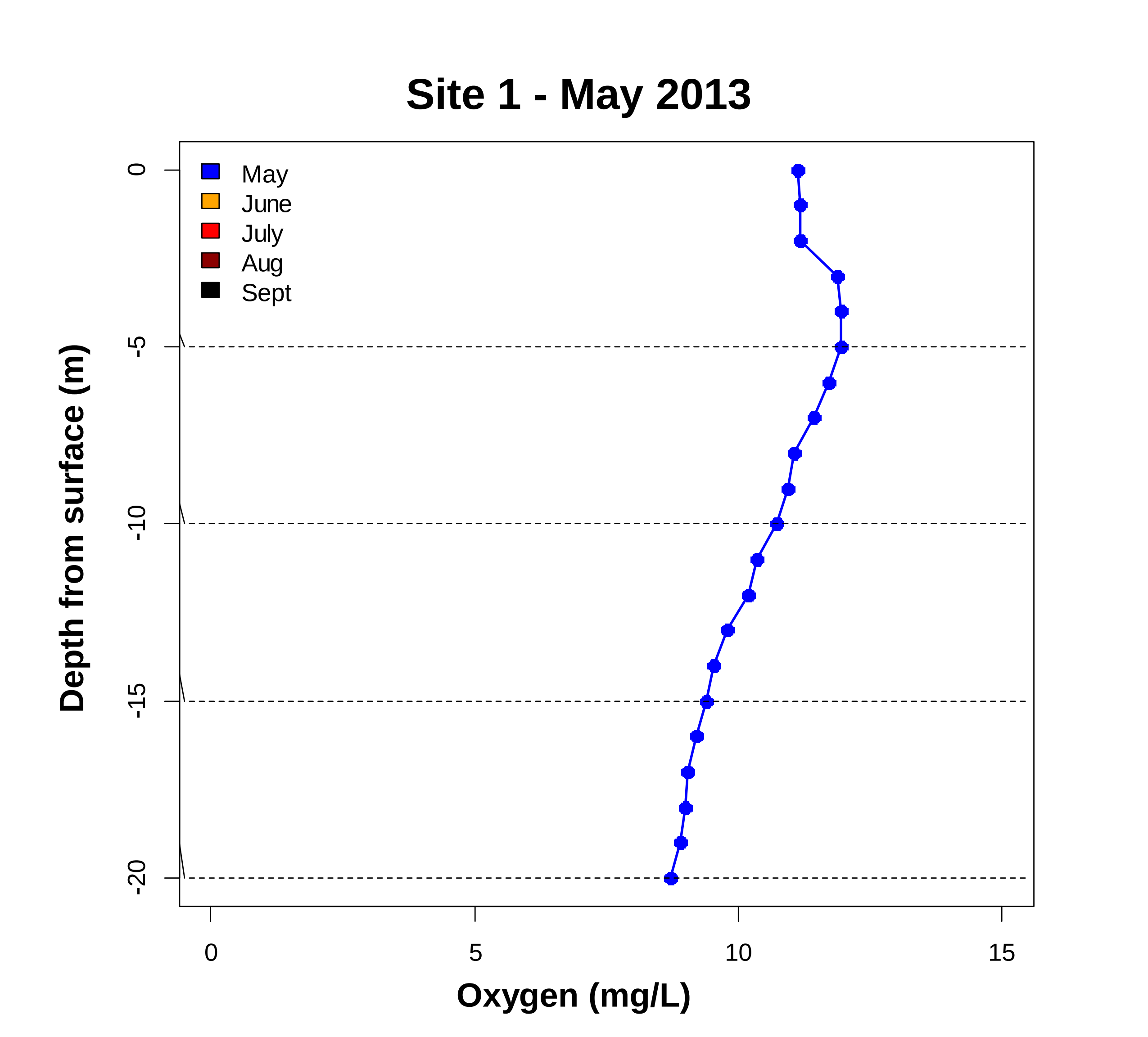


Basins 1-2 have different oxygen profiles than basin 3

At Sites 1-2 *hypolimnetic oxygen depletion* begins after the lake stratifies

This may start as early as April* but usually begins in May or early June, depending on weather conditions

*2015 – may have very early stratification

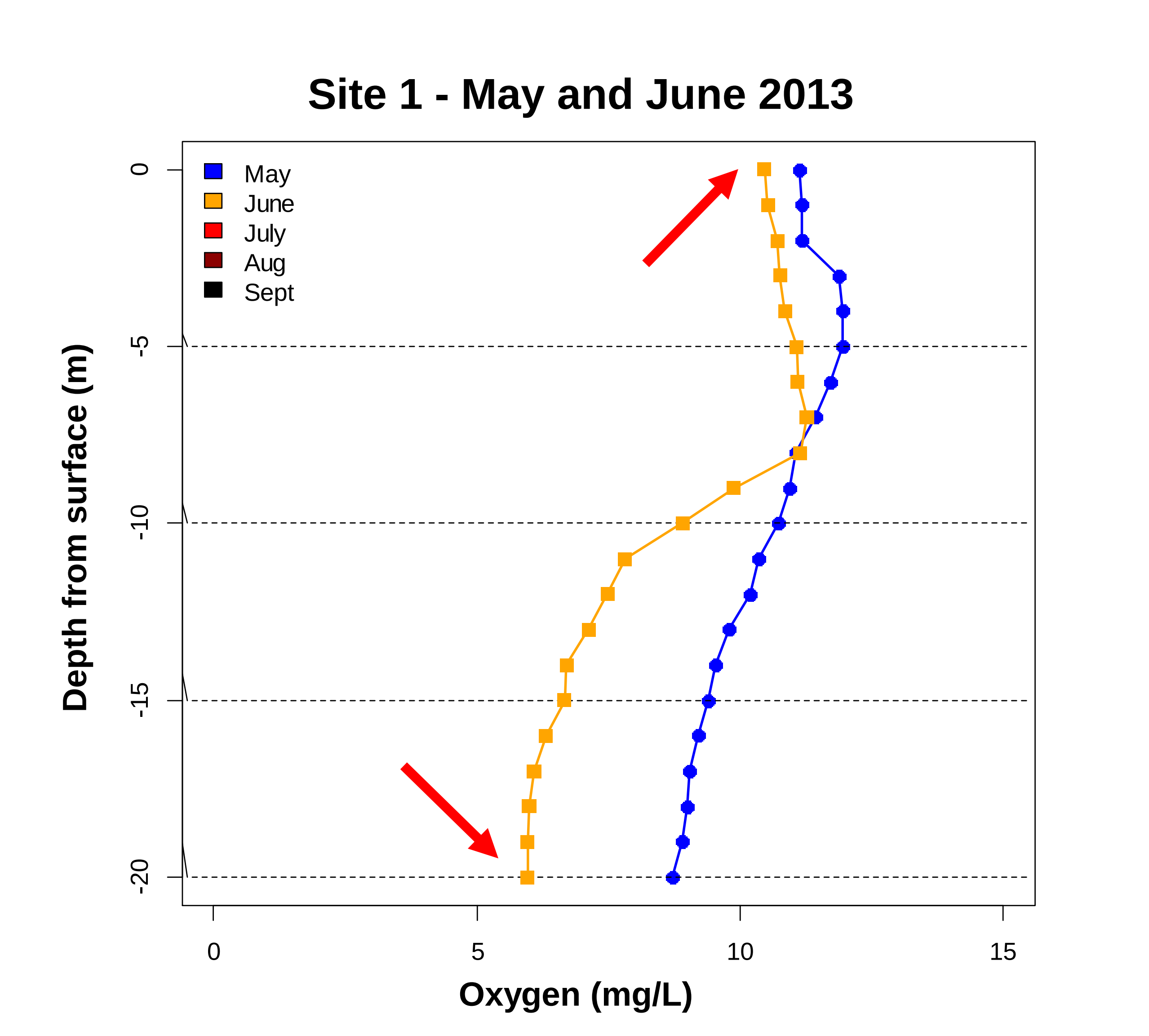


An oxygen sag typically develops by June

By June 2013, oxygen levels were 4.5 mg/L lower at the bottom compared to the surface

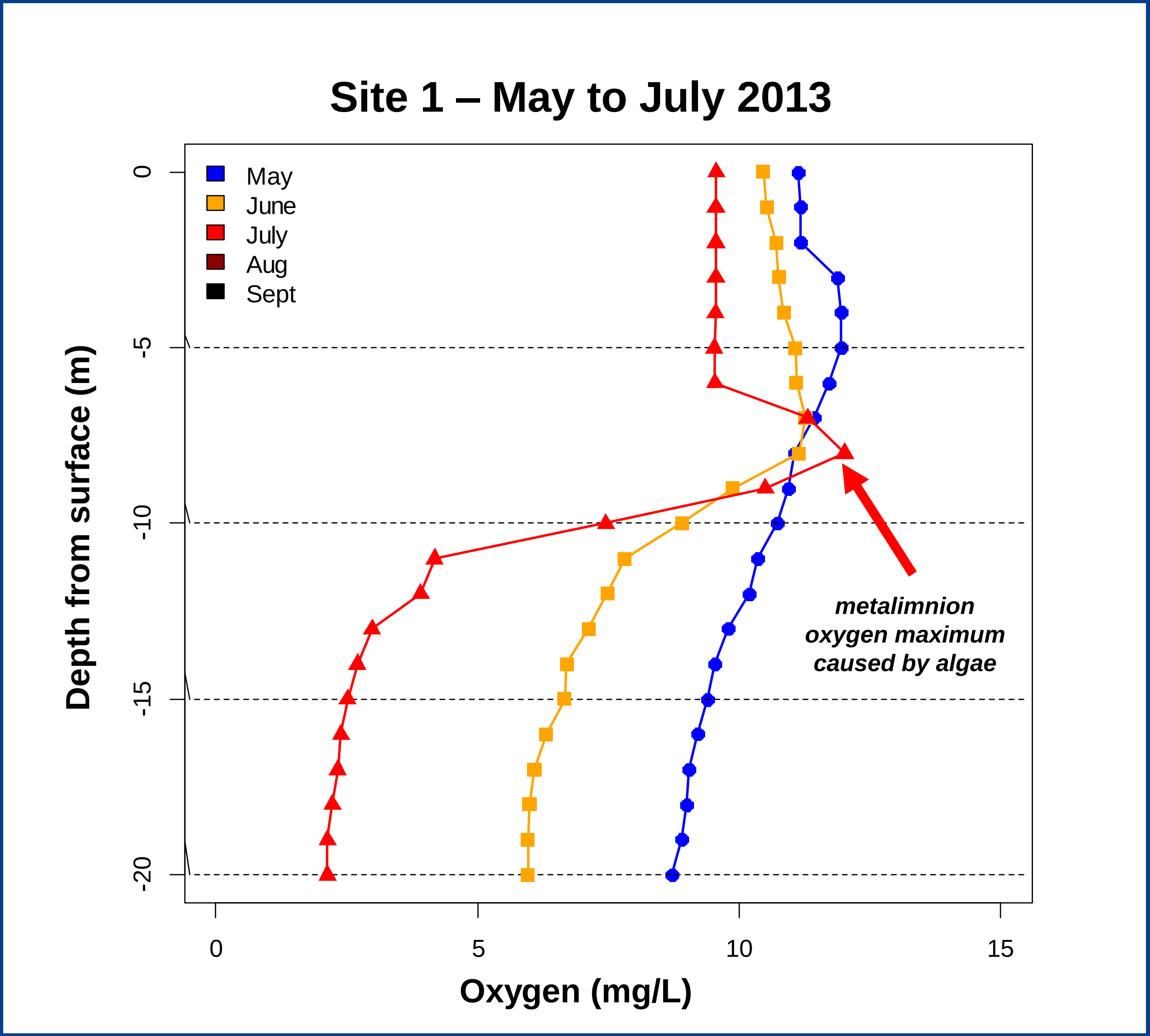
Surface oxygen levels fall slightly at the surface because the water is warmer

- ➔ warm water holds less oxygen than cold water



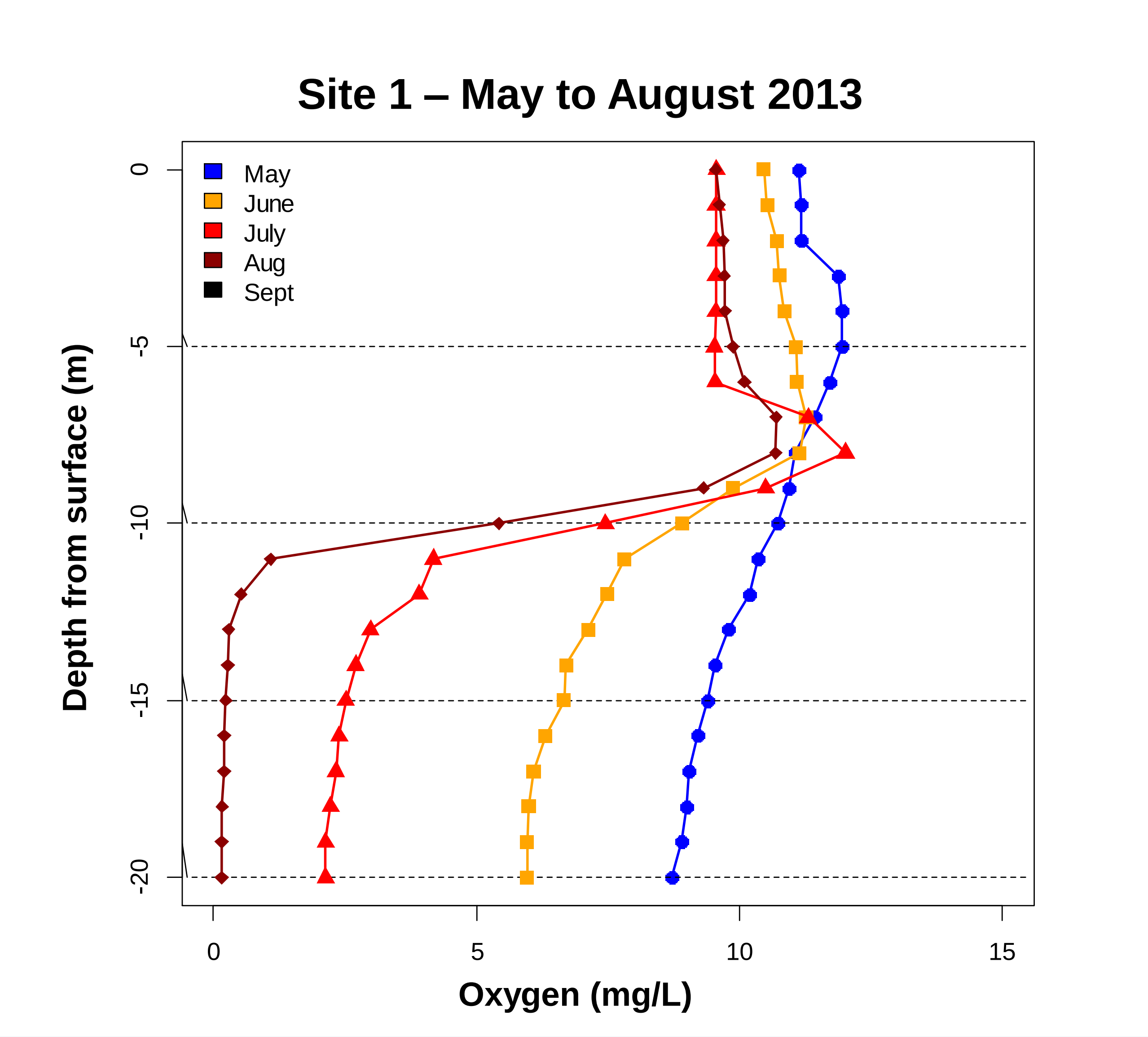
As the summer progresses, the oxygen depletion in the hypolimnion becomes increasingly evident

The bulge between 5-10 meters is a *metalimnetic oxygen maximum* caused by bands of algae

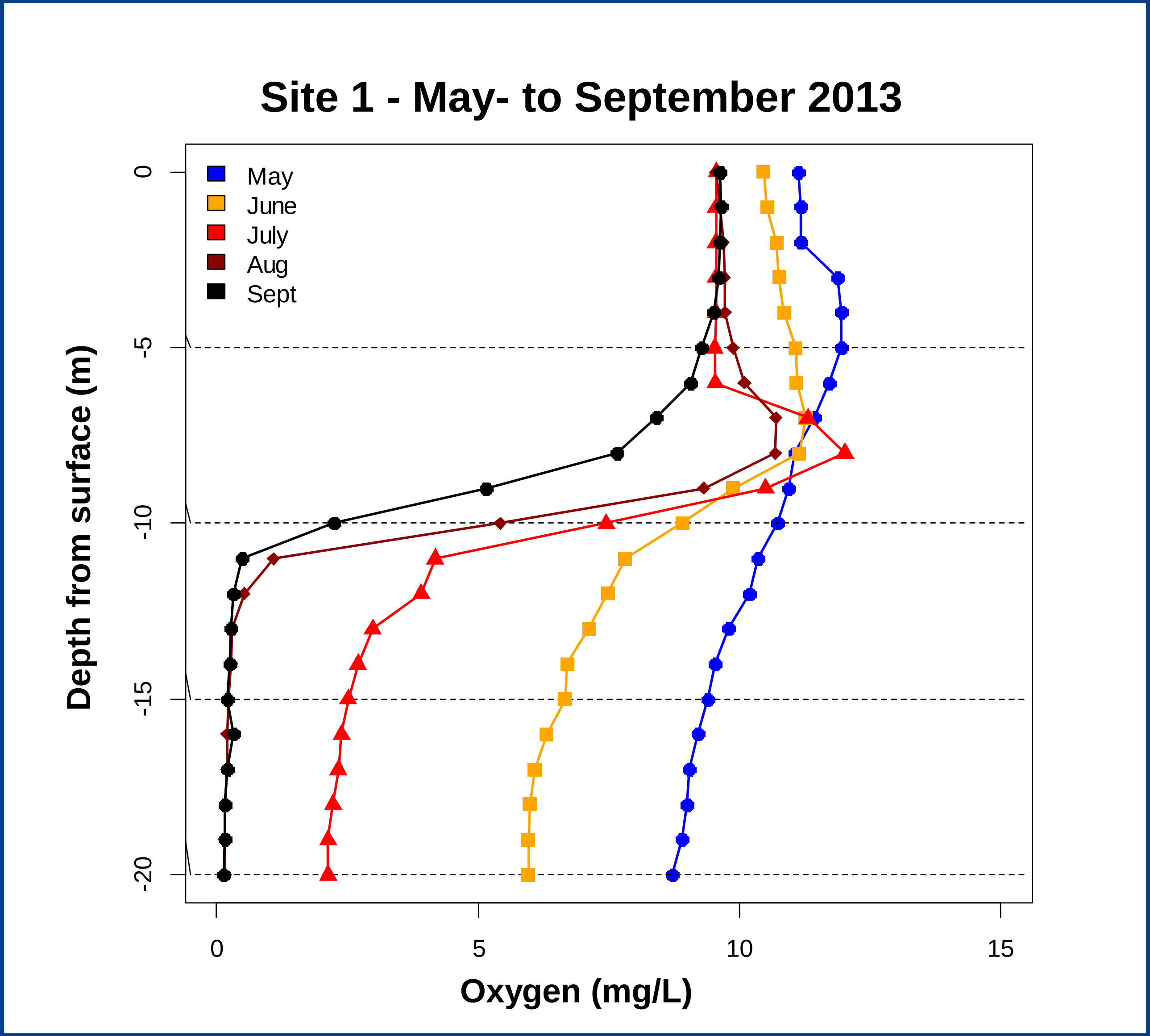


By August, there is almost no oxygen in the hypolimnion

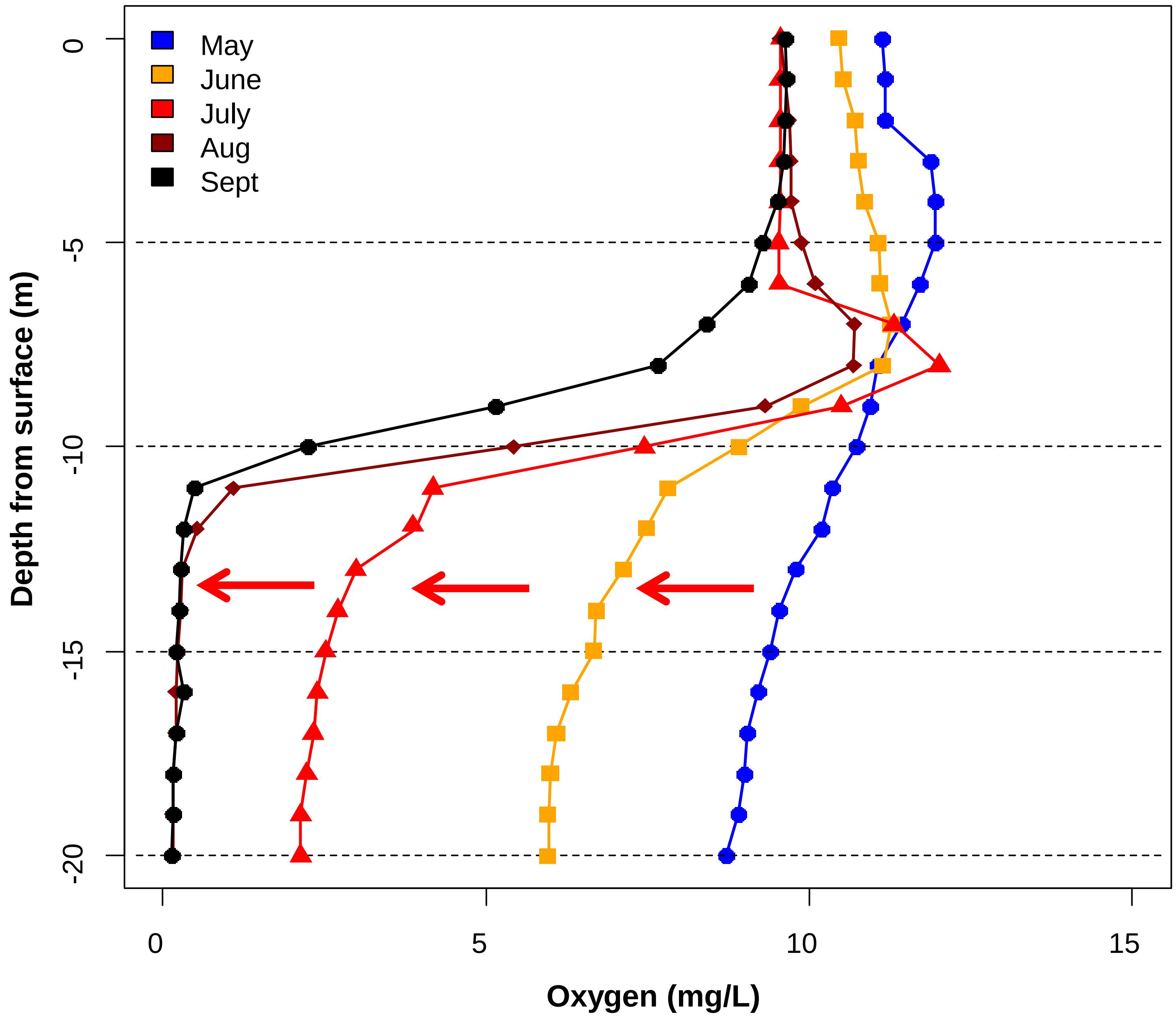
Once oxygen levels fall below ~2 mg/L, the only aquatic organisms that thrive are *anaerobic bacteria*



The September hypolimnion oxygen concentrations resemble August because additional oxygen won't be introduced until destratification (Oct/Nov at Sites 1-2; Dec/Jan at Sites 3-4)



The rate of hypolimnetic oxygen consumption is increasing



Water Quality Problems Associated With Low Dissolved Oxygen

- Loss of aquatic habitat
  - fish need at least 4-6 mg/L dissolved oxygen
- Release of nutrients and other compounds from the sediments
  - Dissolved metals, methylated mercury, hydrogen sulfide
  - Phosphorus

More Phosphorus = More Algae

More Phosphorus = More Algae

Internal sources

Phosphorus released from sediments (low oxygen)

More Phosphorus = More Algae

Internal sources

Phosphorus released from sediments (low oxygen)

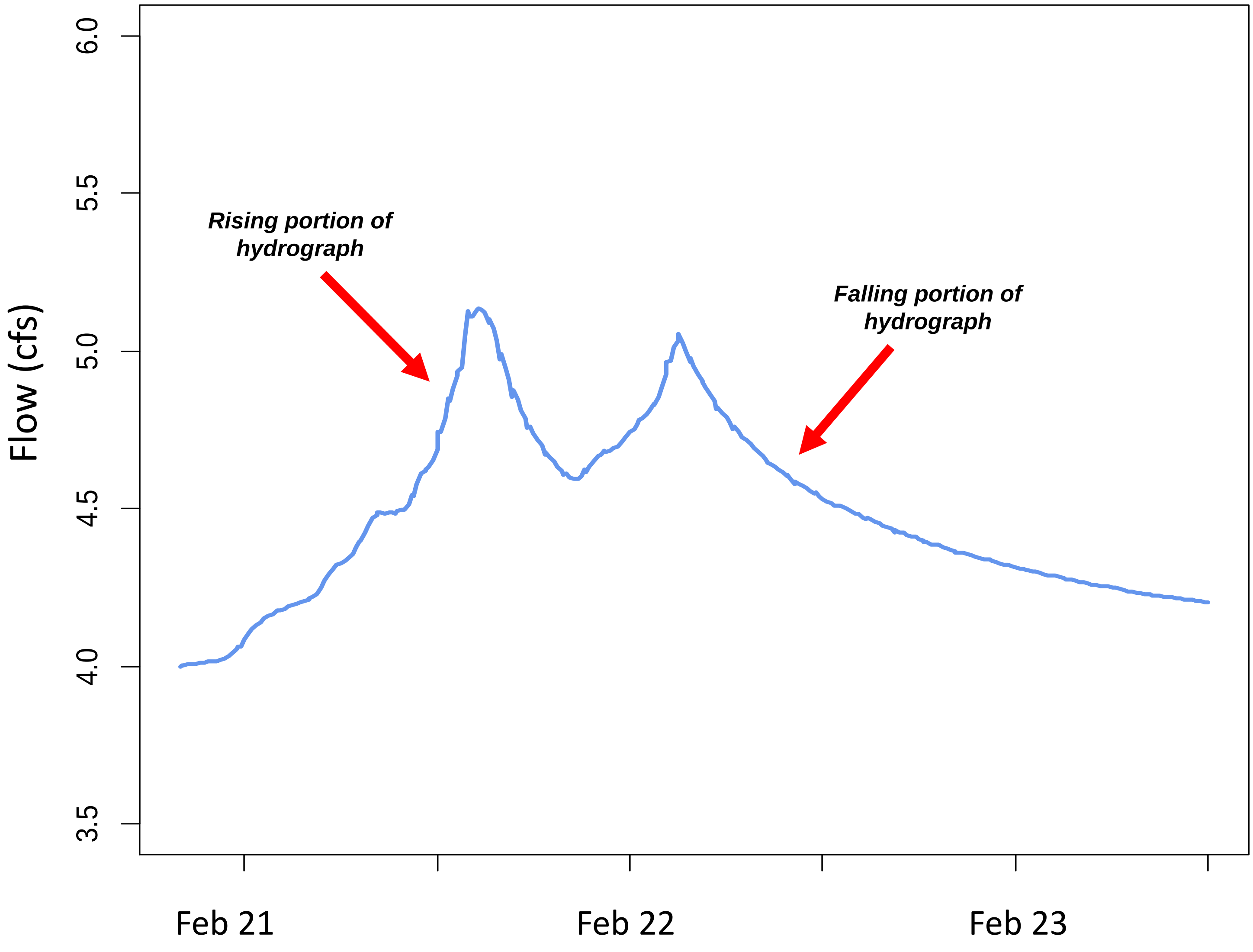
External sources

Phosphorus transported in surface runoff

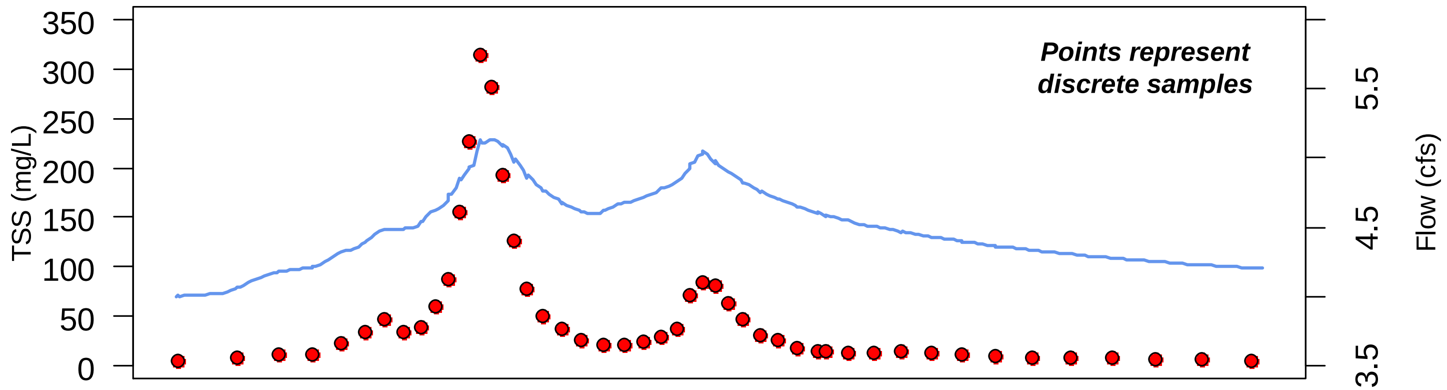
Storm Water Monitoring

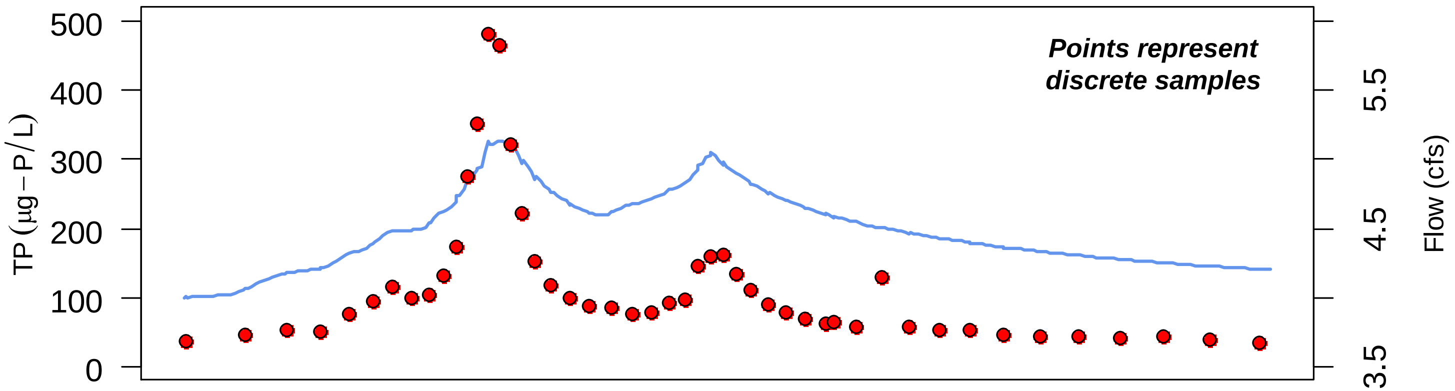
- Samples collected during storms of ≥1 cm in 24-hr
  - At least 7 samples collected during storm event
  - Samples analyzed for total suspended solids and phosphorus
  - Data used to model phosphorus loading into the lake
- 2010-2012: Silver Beach Creek (24 events)
- 2013-2015: Austin, Anderson, Brannian Creeks (14 events)
- 2013-2014: Smith Creek (22 storm events; Beeler M.S. thesis)

Silver Beach Creek Storm Water Monitoring
(Event #23: Feb 20-23, 2012)

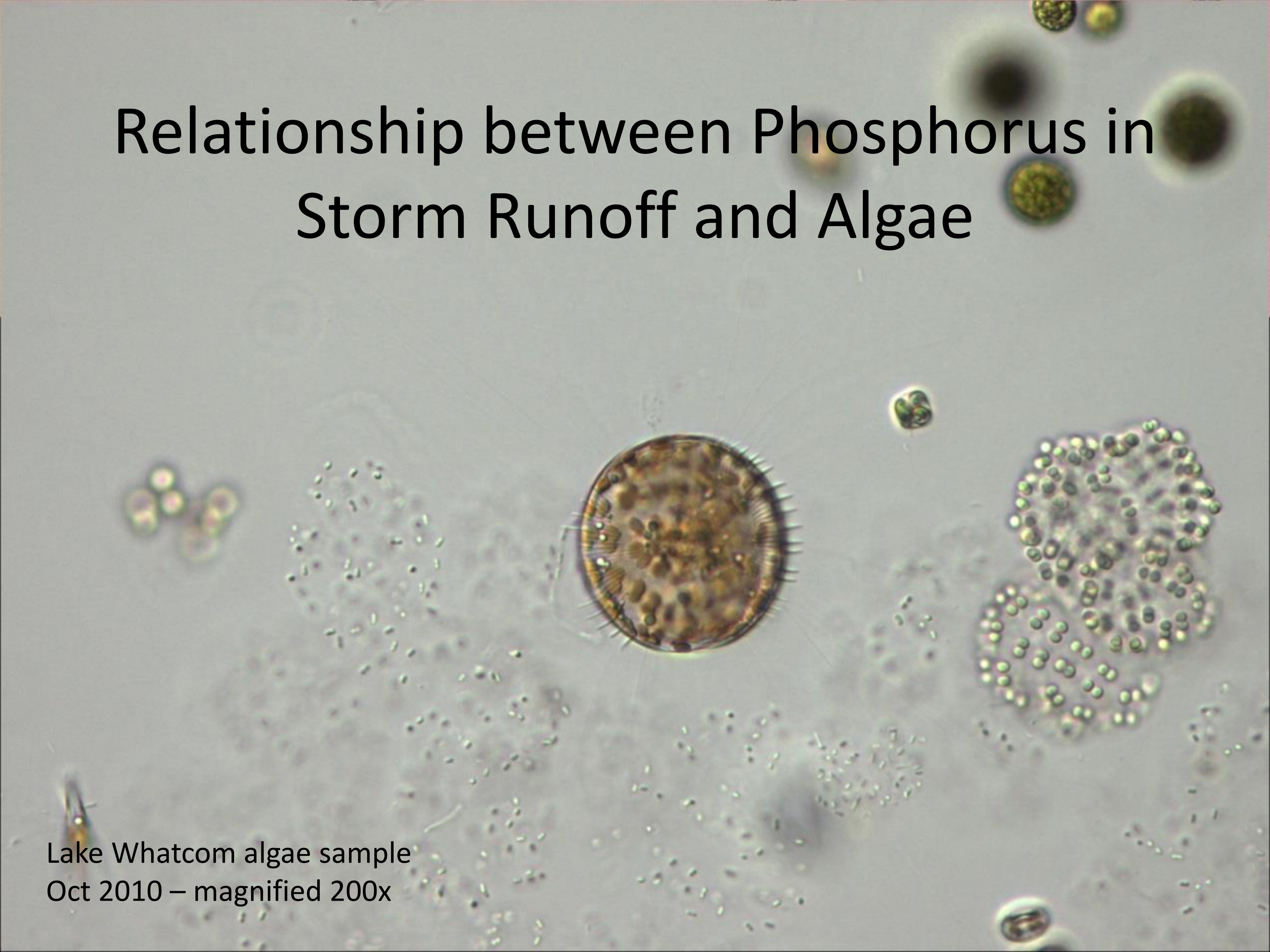


Silver Beach Creek Storm Water Monitoring
(Event #23: Feb 20-23, 2012)



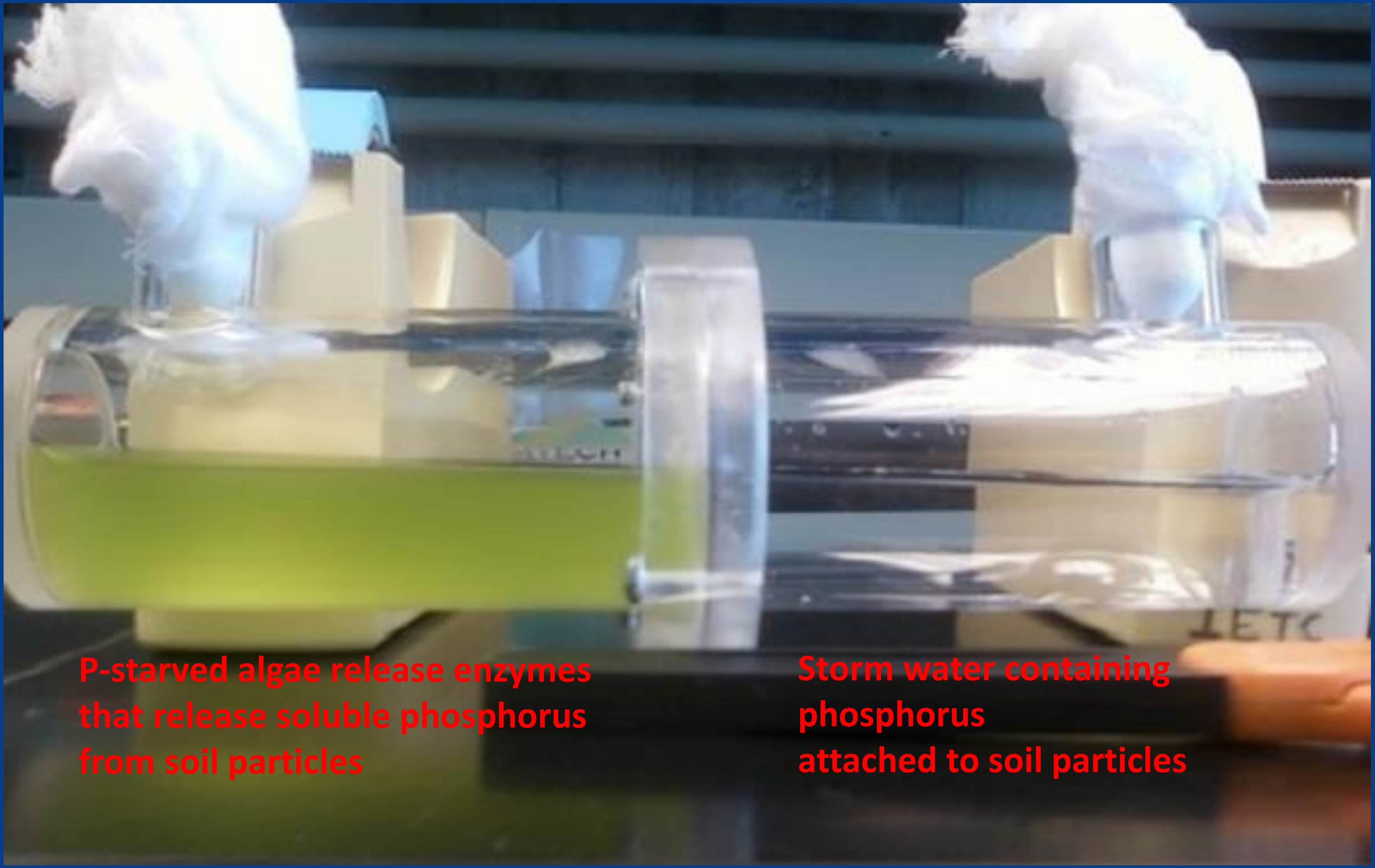


Relationship between Phosphorus in Storm Runoff and Algae



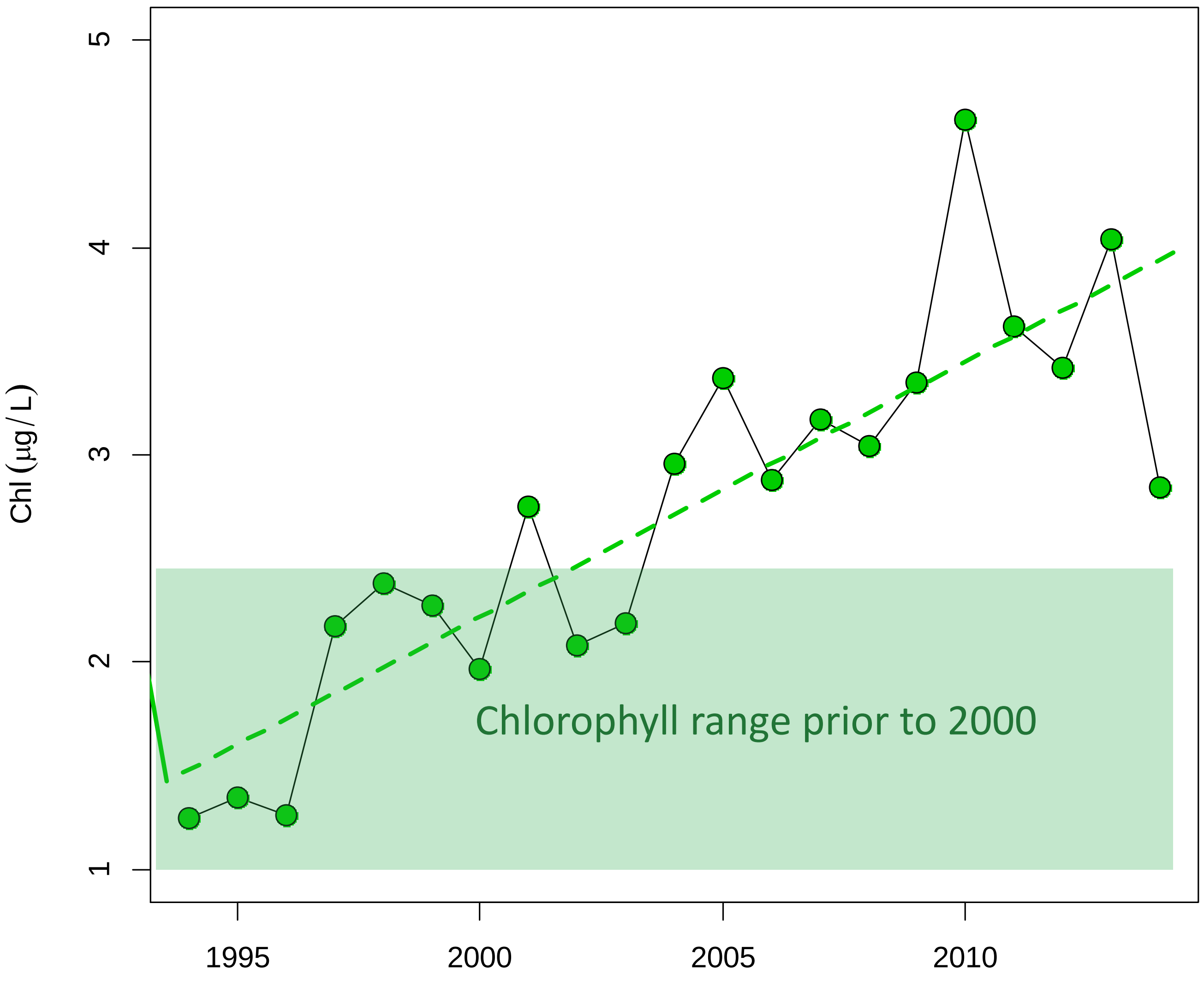
Lake Whatcom algae sample
Oct 2010 – magnified 200x

Although phosphorus enters Lake Whatcom attached to soil particles, it doesn't necessarily stay attached!

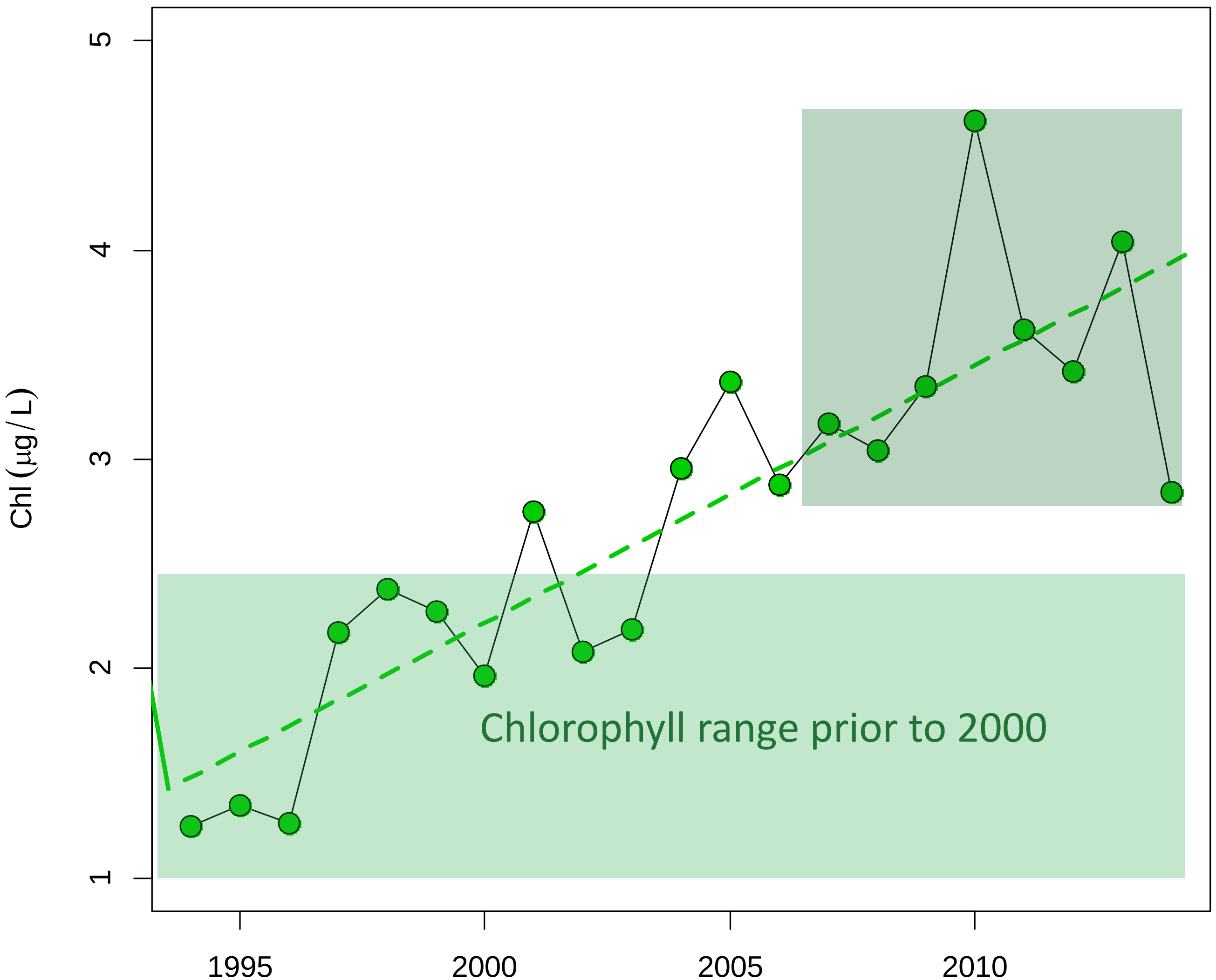


Determining biological available phosphorus in storm water entering Lake Whatcom, WA using the dual culture diffusion apparatus, J. Deacon, 2015. M.S. thesis

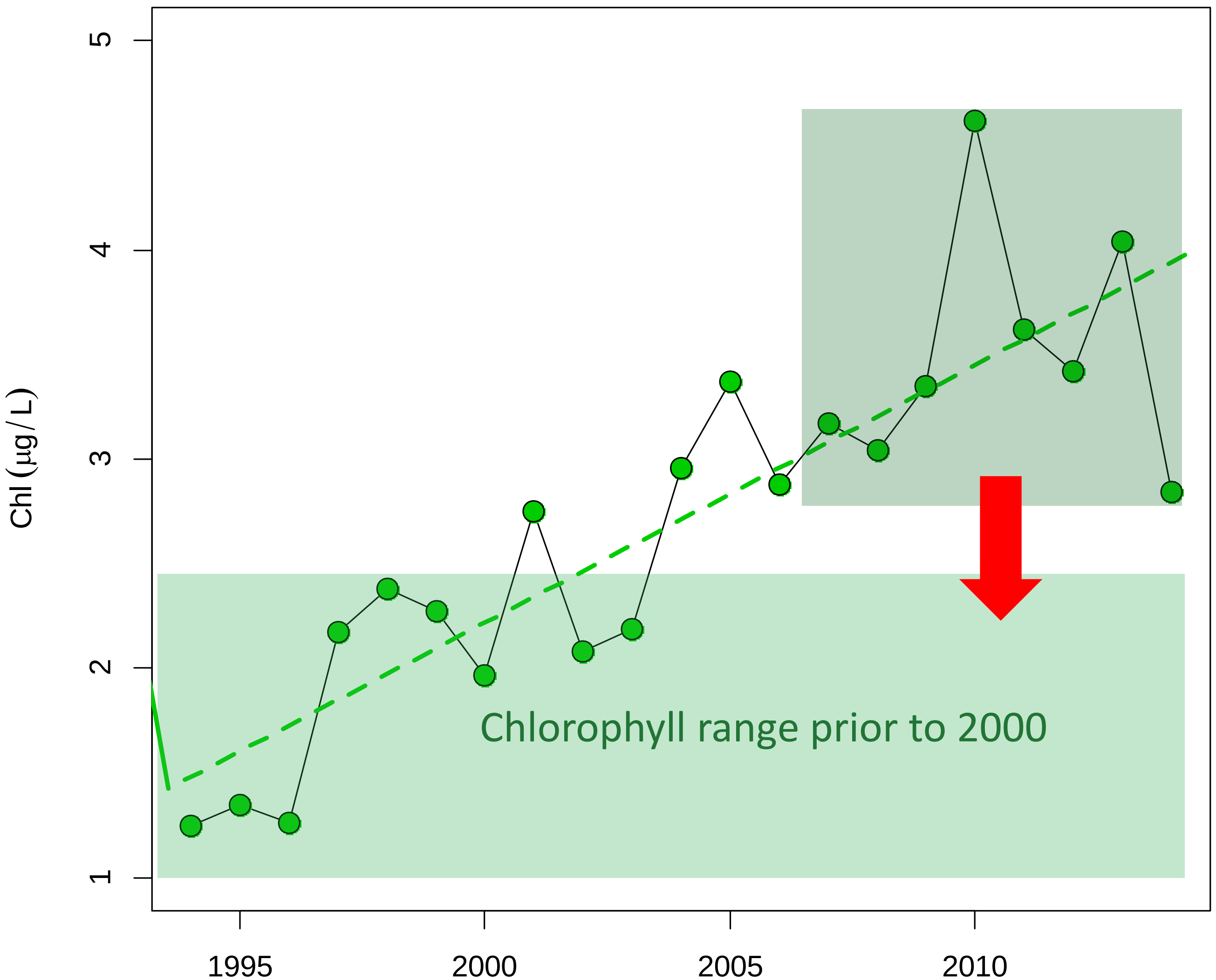
Increasing Chlorophyll at Site 4 in Lake Whatcom



Increasing Chlorophyll at Site 4 in Lake Whatcom



Increasing Chlorophyll at Site 4 in Lake Whatcom



Water Quality Problems Associated With High Concentrations of Algae

- Positive feedback loop between algae and phosphorus
  - Algae remove phosphorus from water and soil particles, causing algal growth
  - Decomposing algae release phosphorus, which causes more algal growth
- Some lakes have toxic algae blooms (currently not a problem in Lake Whatcom)
- Increased drinking water treatment costs
  - Disinfection byproducts (THMs)
  - Taste and odor problems
  - Decreased water filtration rates

Where are we now?

- Lake Whatcom Annual Report summarizes the current conditions
  - Hypolimnetic oxygen levels still low at Site 1
  - Storm runoff carries increased concentrations of sediment and phosphorus into the lake
  - Chlorophyll concentrations (and algal counts) still high throughout the lake

Where are we now?

- Lake Whatcom Annual Report summarizes the current conditions
  - Hypolimnetic oxygen levels still low at Site 1
    - → We can’t do much about this directly, but it should improve if the amount of algae in the lake can be reduced

Where are we now?

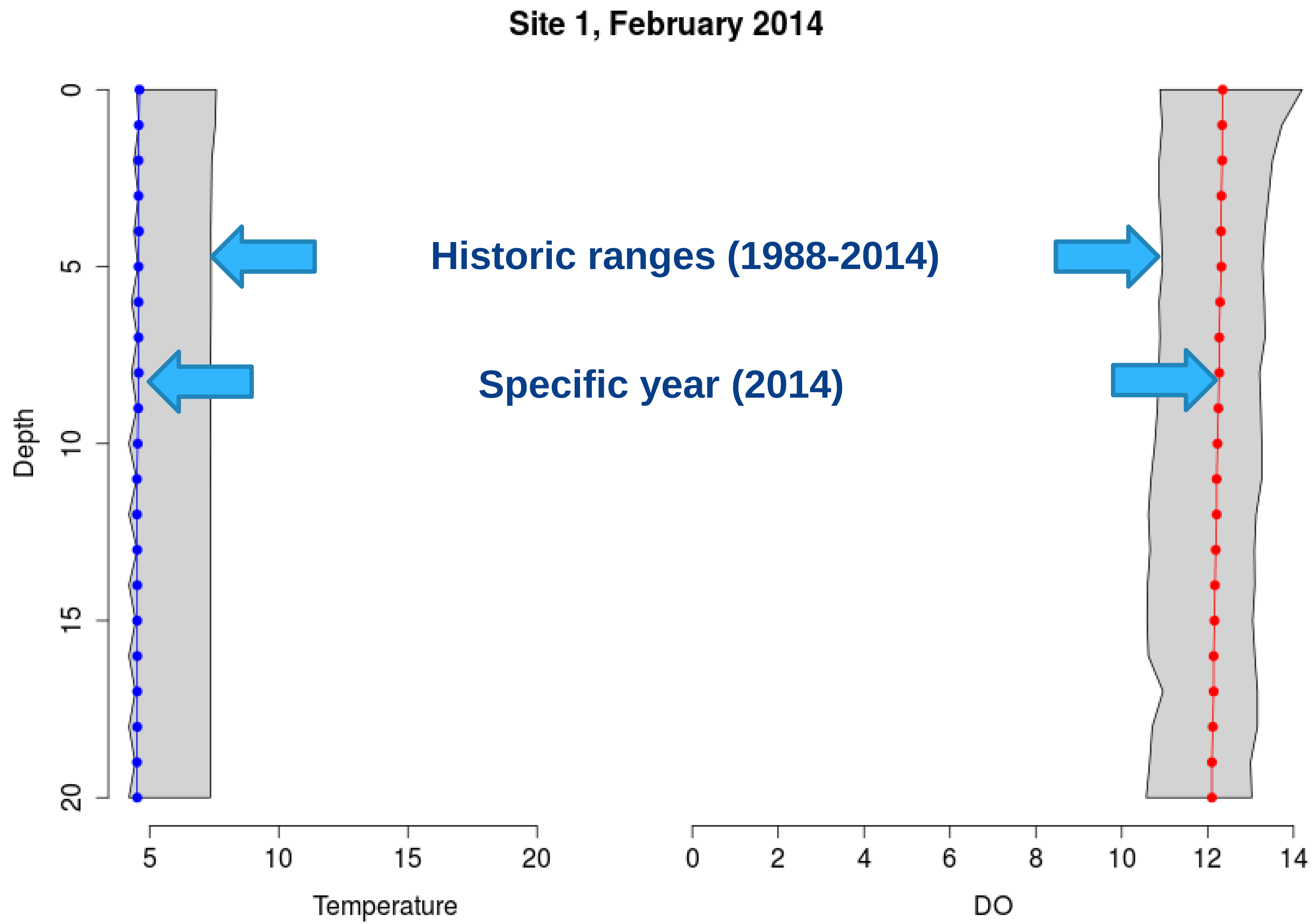
- Lake Whatcom Annual Report summarizes the current conditions
  - Storm runoff carries increased concentrations of sediment and phosphorus into the lake
    - The TMDL is designed to reduce phosphorus loading from the watershed
    - This will ultimately reduce the amount of algae in the lake

Where are we now?

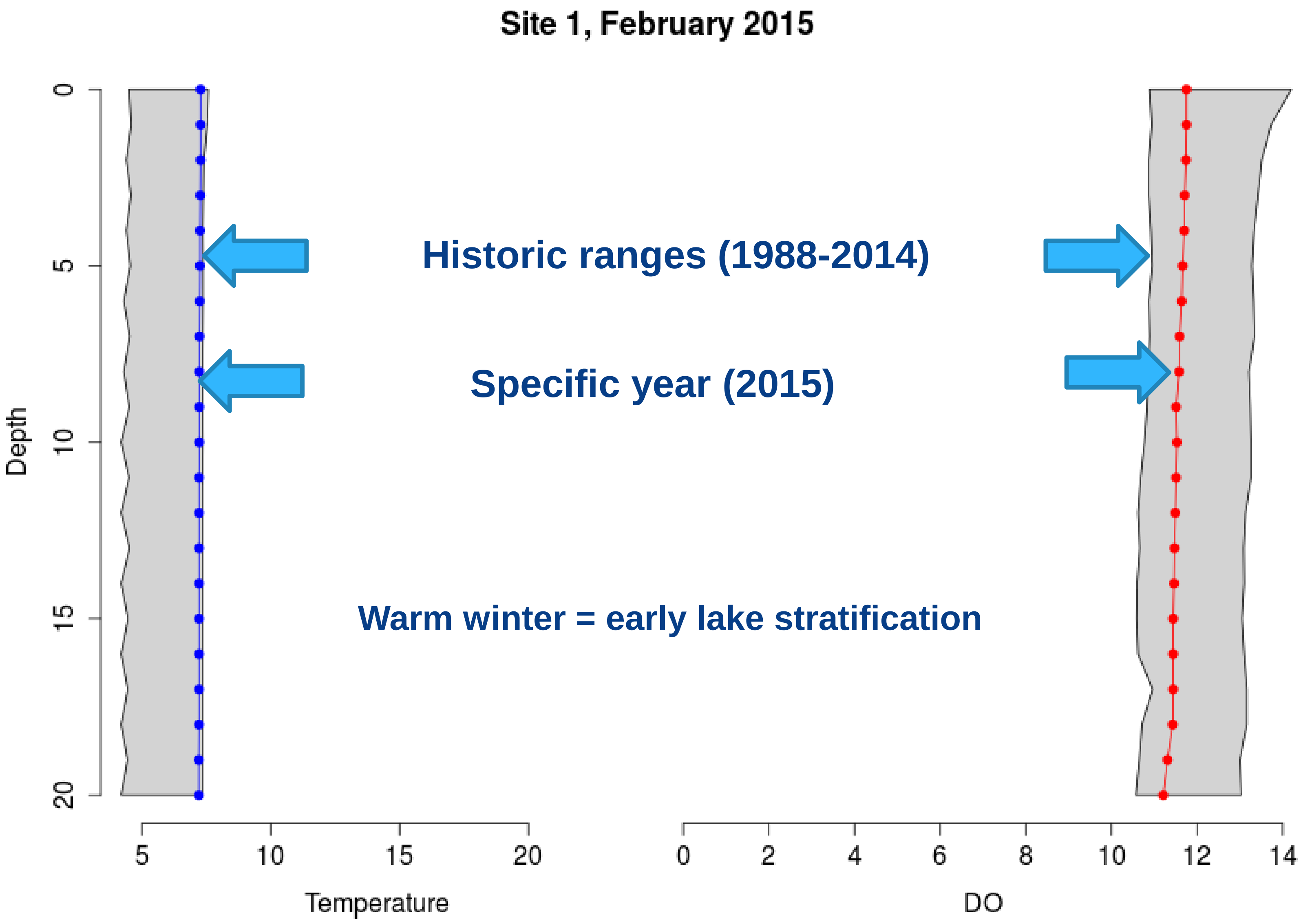
- Lake Whatcom Annual Report summarizes the current conditions
  - Chlorophyll concentrations (and algal counts) still high throughout the lake
    - This will improve (slowly) if we reduce the amount of phosphorus entering the lake
    - To address current water quantity requirements, source water pretreatment may be needed

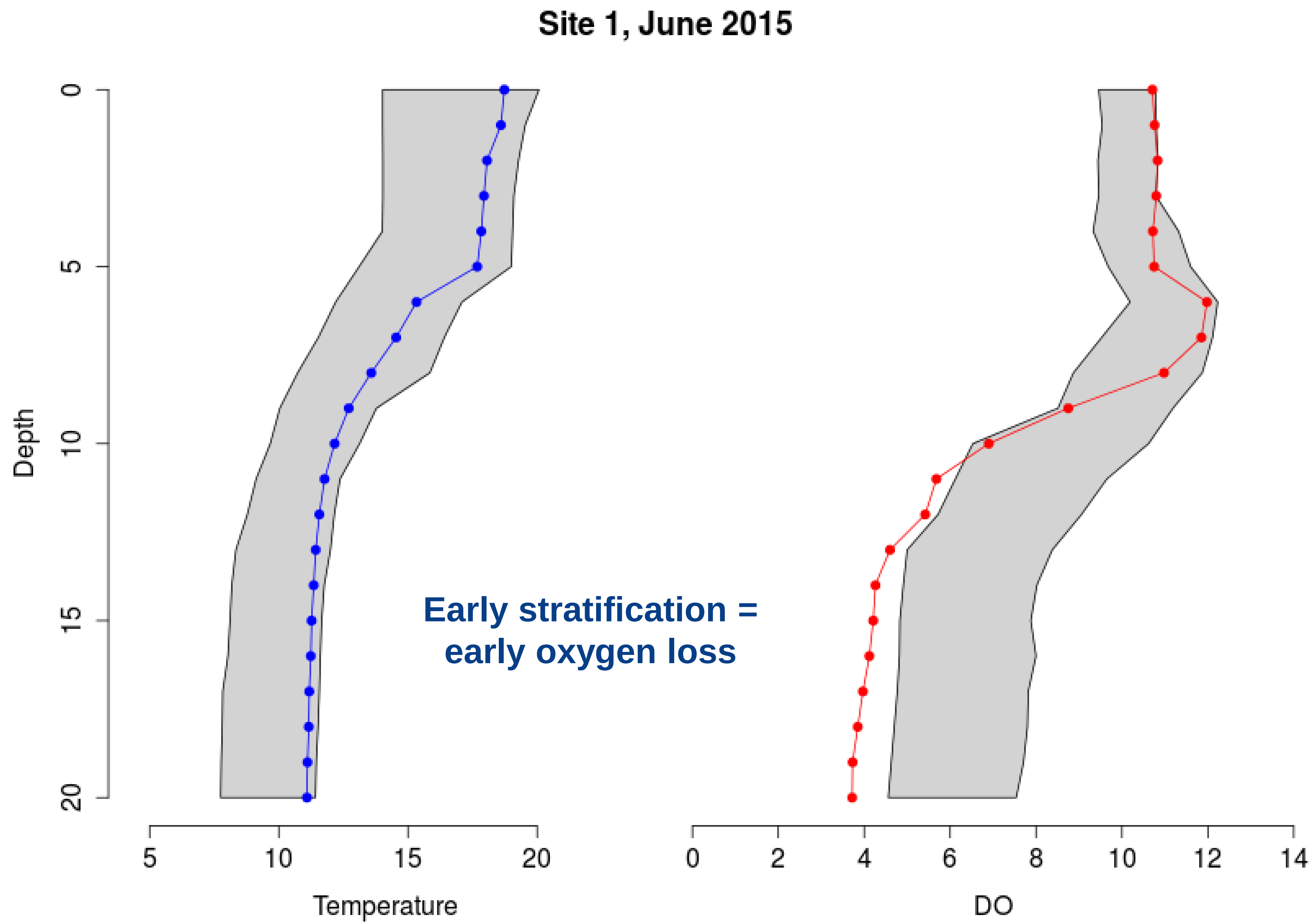
2015 – Not a Typical Year

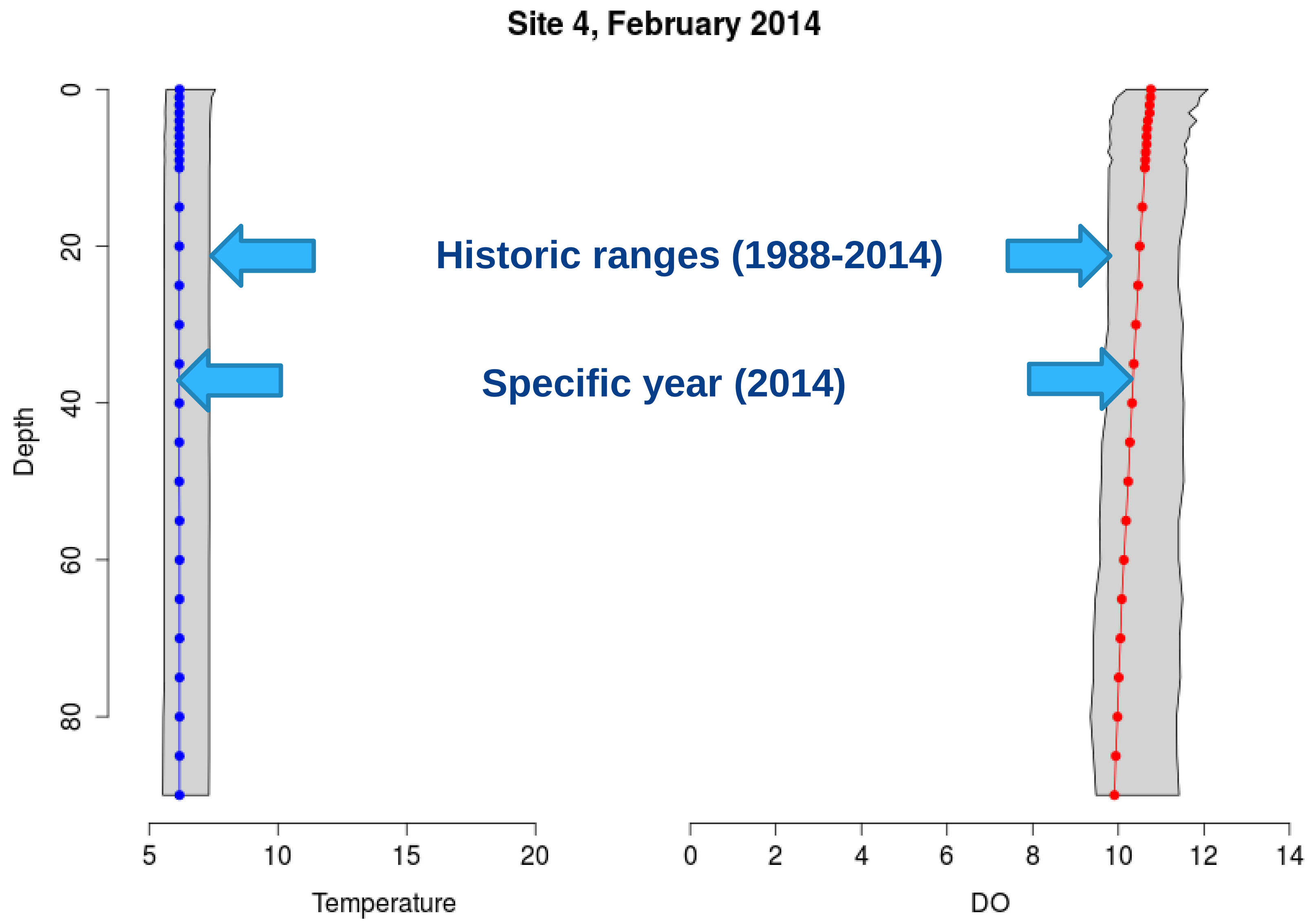
The Feb-June 2015 weather has resulted in temperature and dissolved oxygen profiles that are unlike any patterns measured in the past 30 years



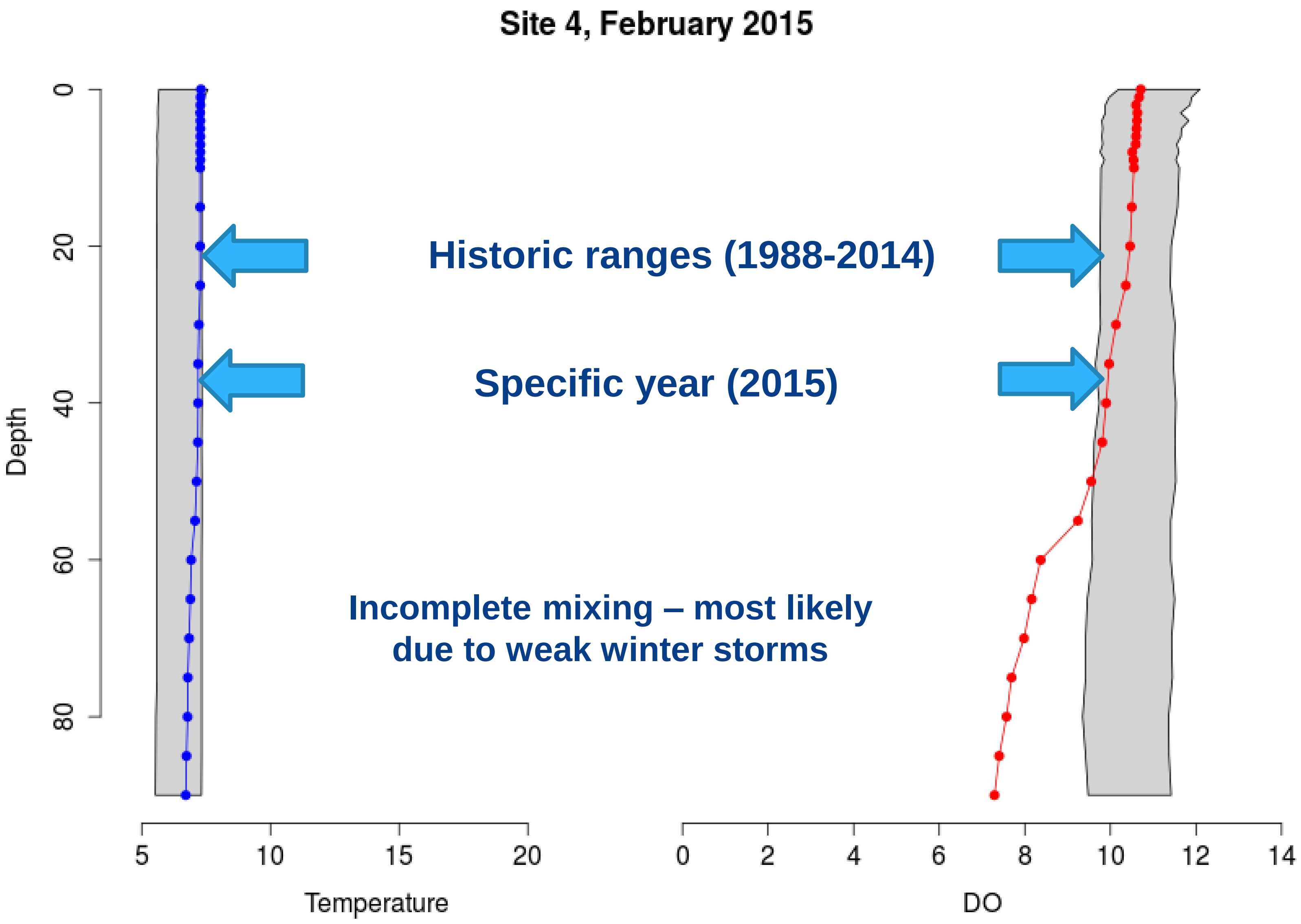
Site 1, February 2014
Historic ranges (1988-2014)
Specific year (2014)
Depth
0
5
10
15
20
5
10
15
20
Temperature
0
2
4
6
8
10
12
14
DO


Site 1, February 2015
Historic ranges (1988-2014)
Specific year (2015)
Warm winter = early lake stratification
Depth
0
5
10
15
20
5
10
15
20
Temperature
0
2
4
6
8
10
12
14
DO

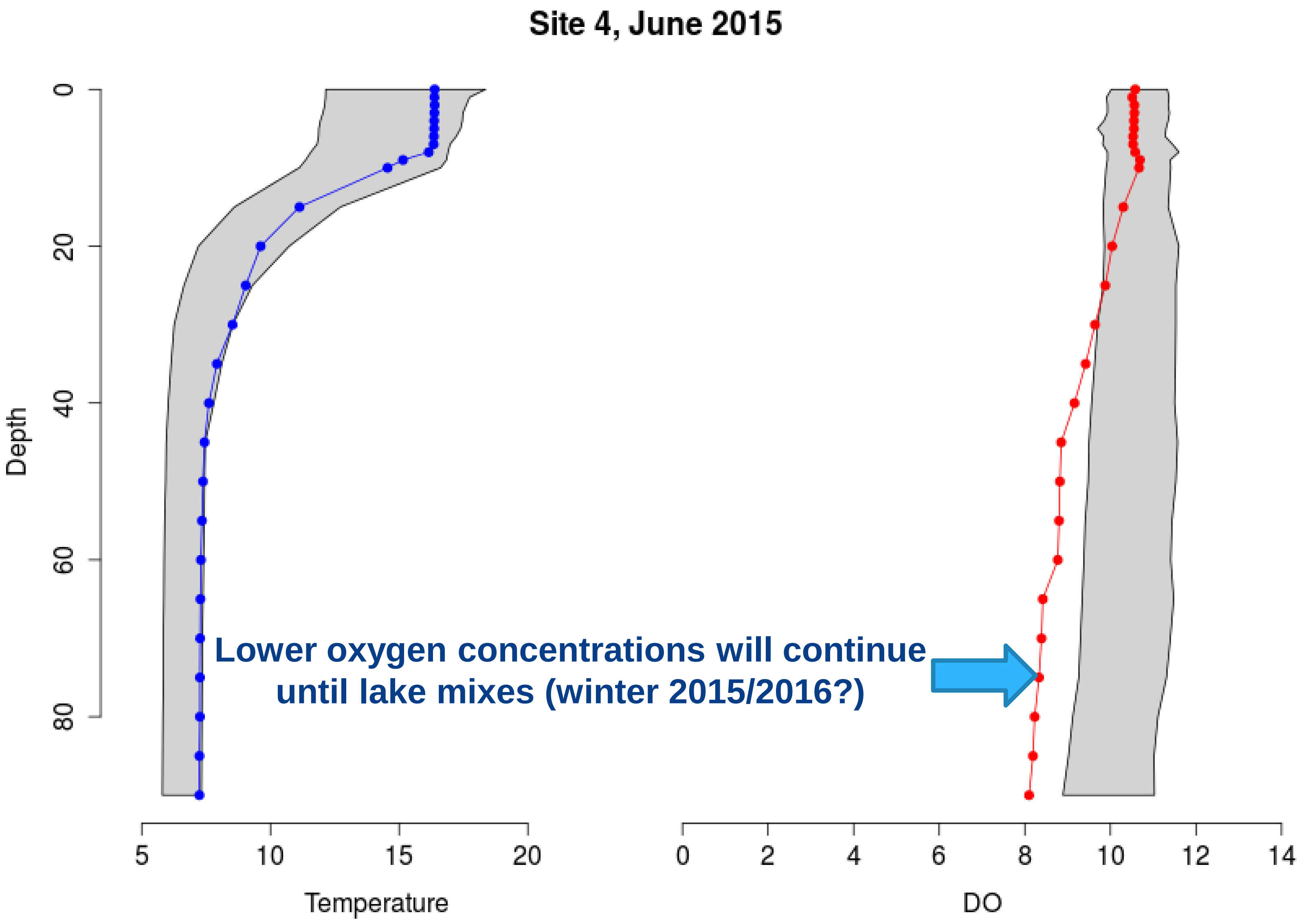

Site 1, June 2015
Depth
0
5
10
15
20
5
10
15
20
Temperature
0
2
4
6
8
10
12
14
DO
Early stratification =
early oxygen loss



Site 4, February 2014
Historic ranges (1988-2014)
Specific year (2014)
Depth
0
20
40
60
80
5
10
15
20
Temperature
0
2
4
6
8
10
12
14
DO



Site 4, February 2015
Historic ranges (1988-2014)
Specific year (2015)
Incomplete mixing – most likely
due to weak winter storms
Depth
0
20
40
60
80
5
10
15
20
Temperature
0
2
4
6
8
10
12
14
DO


Site 4, June 2015
Depth
0
20
40
60
80
Temperature
5
10
15
20
DO
0
2
4
6
8
10
12
14
Lower oxygen concentrations will continue
until lake mixes (winter 2015/2016?)

Thanks!

Mike Hilles

Joan Vandersypen

Marilyn Desmul

Dr. Robert Mitchell

Dr. Geoffrey Matthews

undergraduate and graduate students

working on the Lake Whatcom Project