Review of King County's Lake Buoy Monitoring System

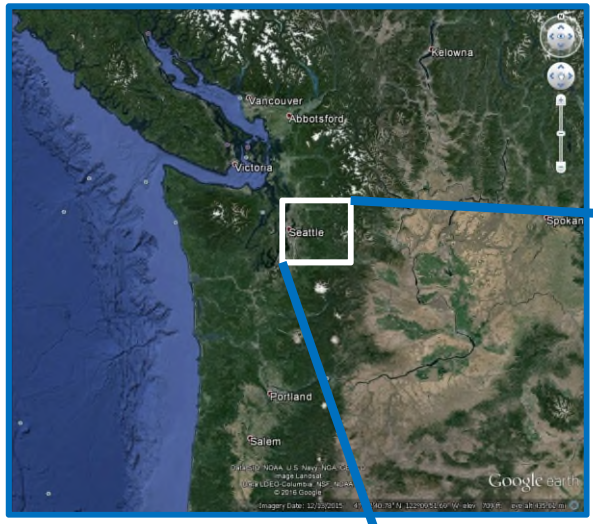
10th National Monitoring Conference

Curtis DeGasperi
King County Water and Land Resources Division

May 5, 2016

King County

Locations


Kelowna
Vancouver
Abbotsford
Victoria
Seattle
Spokan
Portland
Salem
Google earth

Shoreline
Bothell
Cottage Lake
Duvall
Kirkland
Redmond
Washington buoy
Ames Lake
Sammamish
Bellevue
Seattle
Sammamish buoy
Issaquah
White Center
Renton
Burien
Vashon
SeaTac
Cascade-Fairwood
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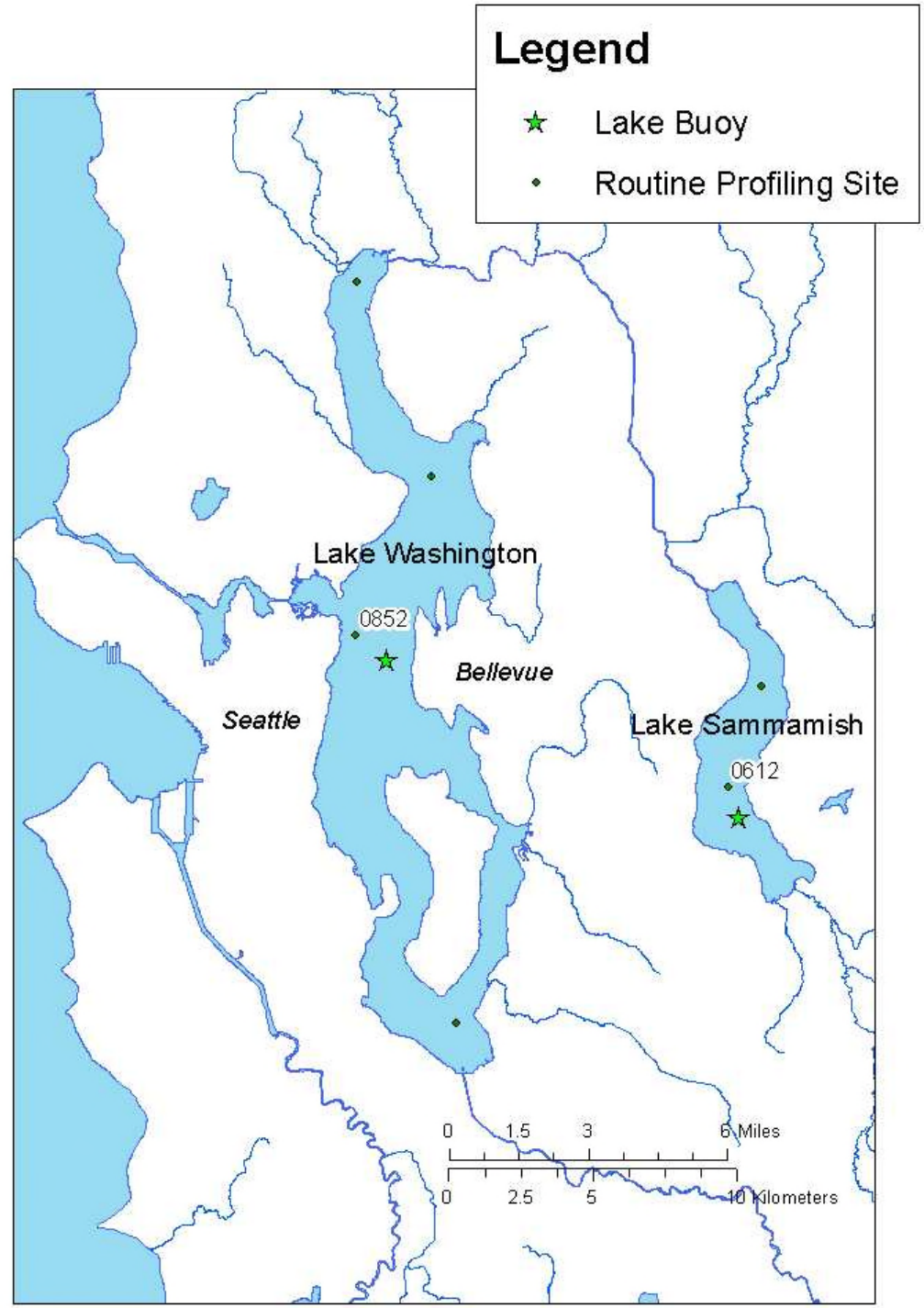
Google earth
Imagery Date: 6/8/2015 47°36'01.71" N 122°11'11.17" W elev 46 ft eye alt 23.41 mi

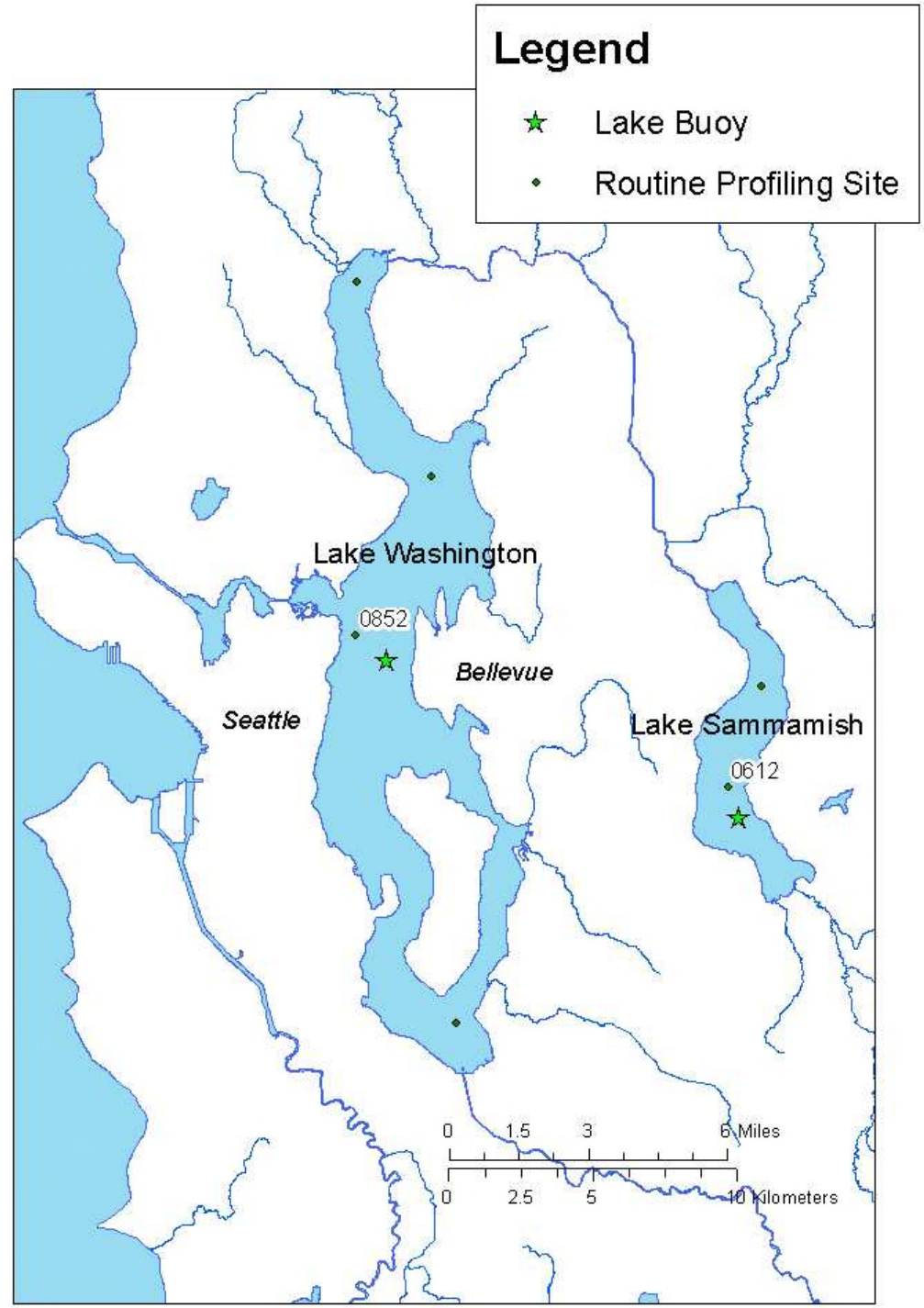
Physical Information

	Washington	Sammamish
Drainage Basin Area	357,760	57,000 ac
Lake Surface Area	21,500	4,900 ac
Lake Volume	2,350,000	283,860 ac-ft
Mean Depth	108	58 ft
Maximum Depth	214	105 ft
Mean Residence Time	2.3	1.8 years



Physical Information

	Washington	Sammamish
Drainage Basin Area	1,448	230 km^2
Lake Surface Area	87.6 km^2	19.8 km^2
Lake Volume	2.9×10^9	3.5×10^8 m^3
Mean Depth	32.9	17.7 m
Maximum Depth	65.2	32 m
Mean Residence Time	2.3	1.8 years



History of Profiling Program

- RUSS
  - 2001-2006

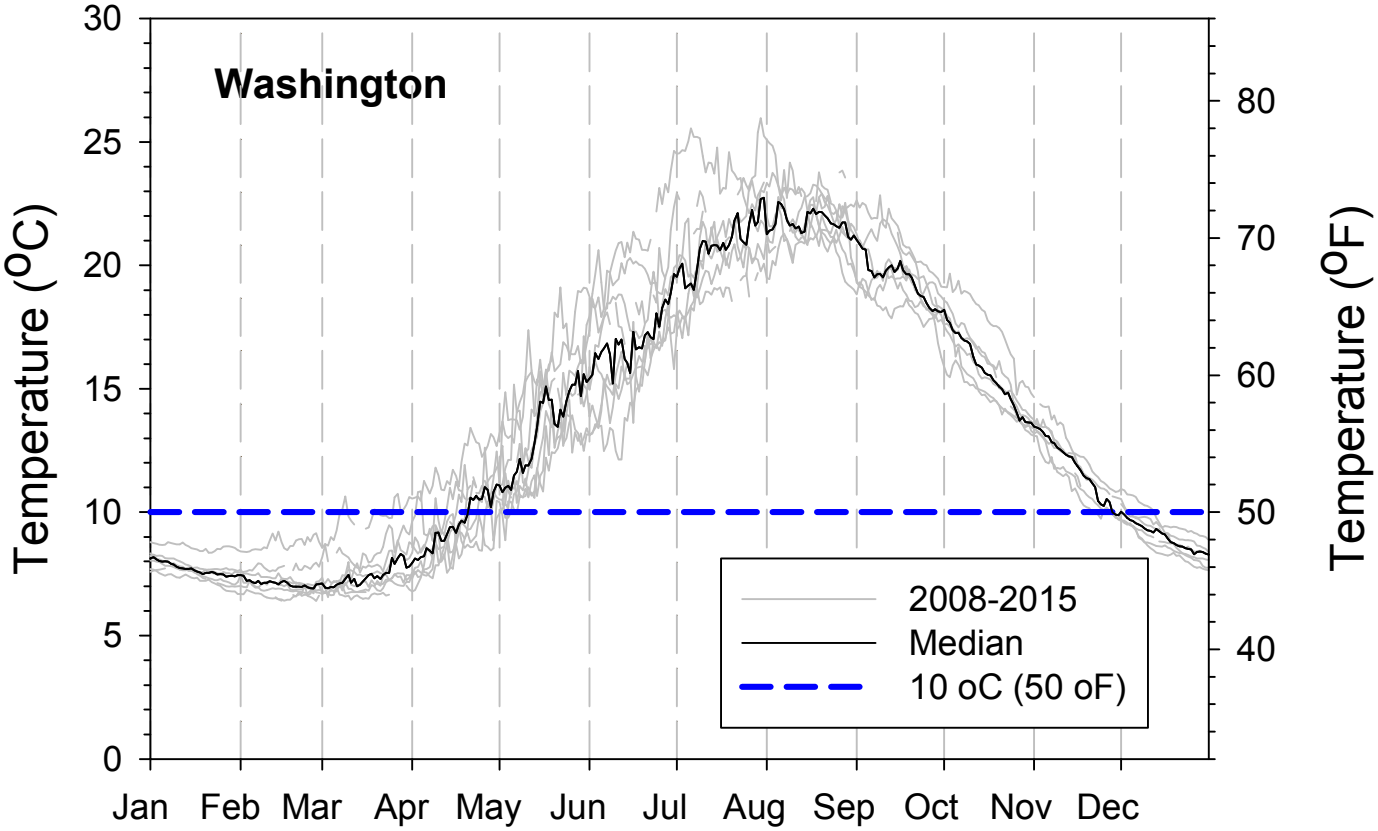
- YSI Platforms
  - 2007-present

Why Robotic Profiling?

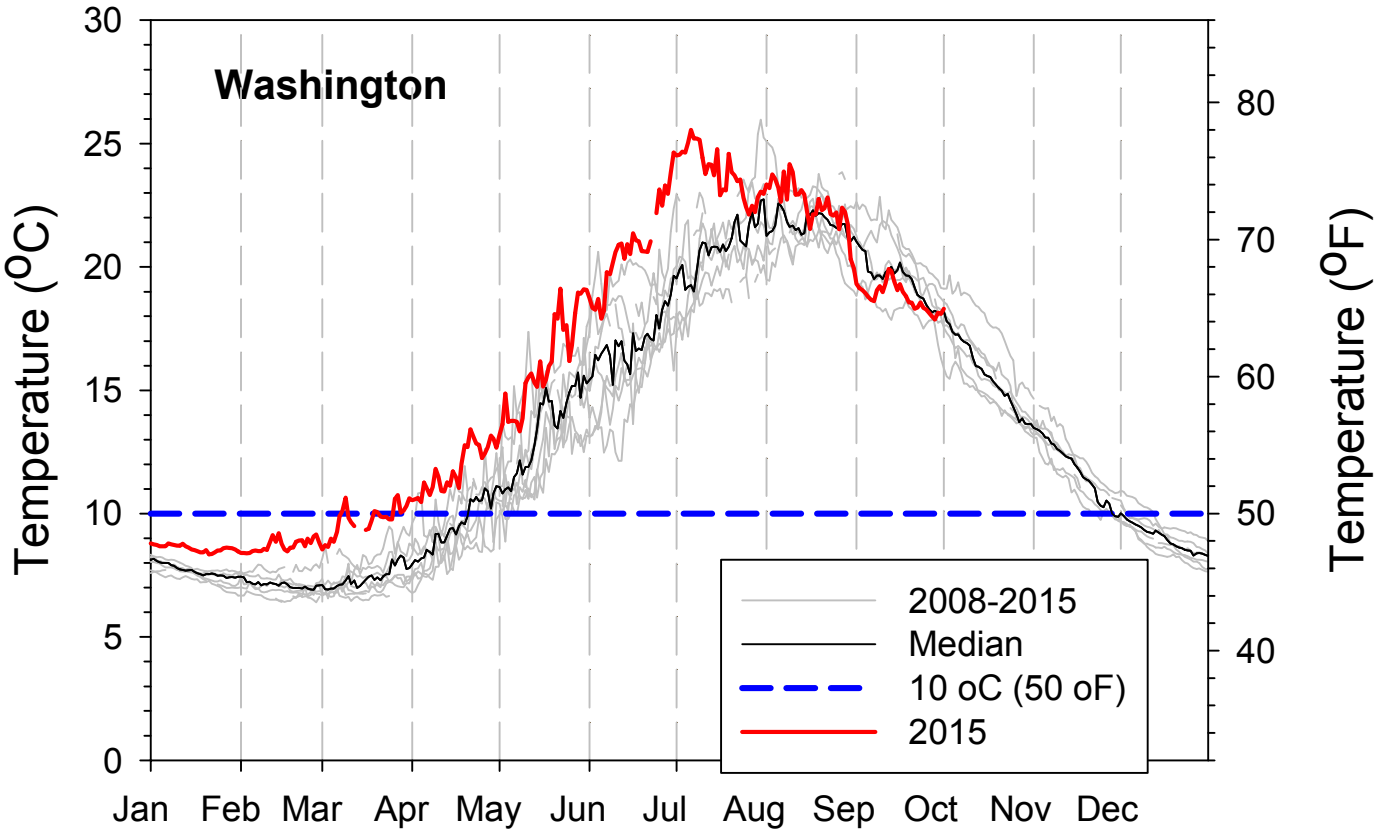
- Near real time data of scientific, resource management, and public interest

- High frequency data potentially helpful in separating the effects of Eutrophication (or Oligotrophication) and Climate Change
  - Natural Variation and Human Caused Change

Lake Swimmers



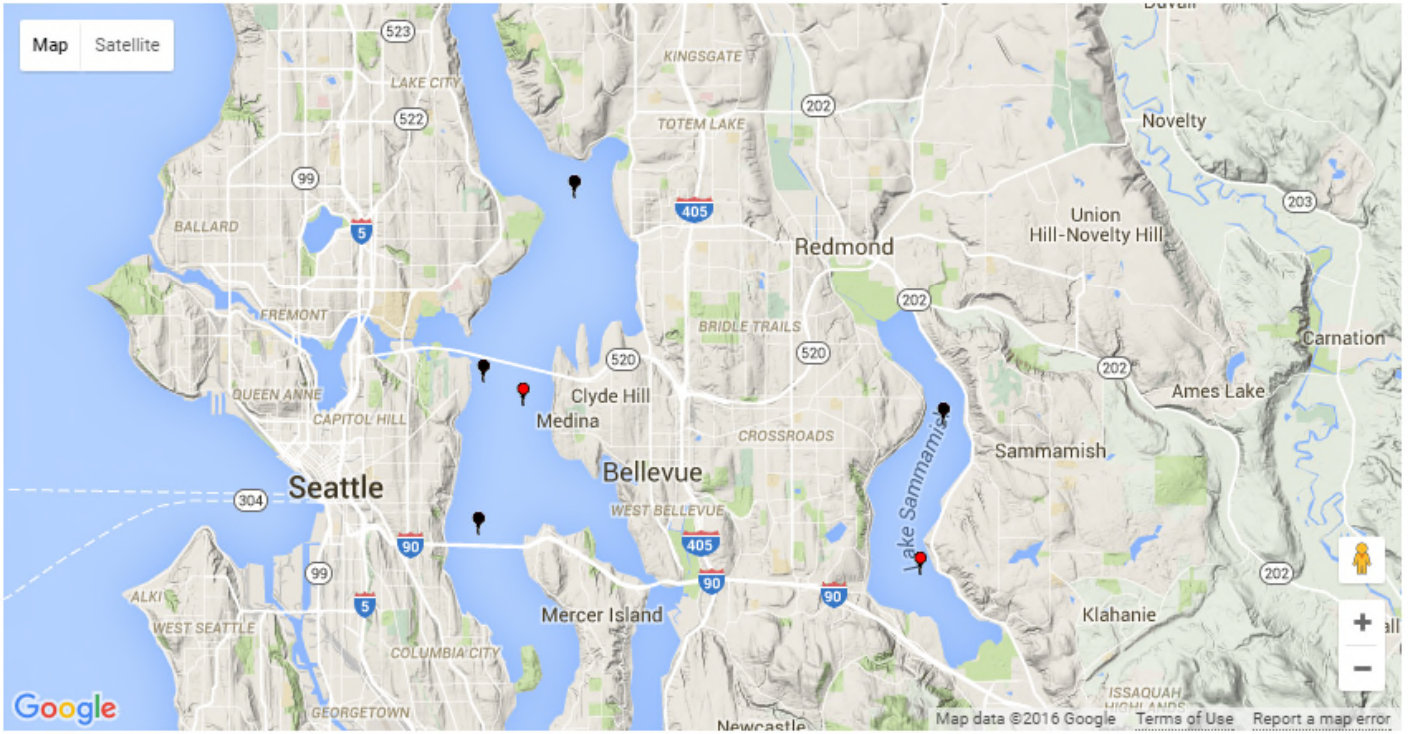
Lake Swimmers



Water and land services
Lakes

- Introduction
- Lakes list
- Major lakes data
- Lake buoy data
  - Latest Weather
  - Latest Profiles
  - Historical Profile Plot
  - Historical Contour Plot
  - View or Download Data
  - Data Quality Control
  - Buoy Specifications
  - Disclaimer
  - About This Site
  - Data Entry
- Swimming beach data
- Small lakes data and info
- Stewardship +
- Fact sheets
- Aquatic plants
- Documents

Lake buoy data



active site inactive site

If you have question on this site, please contact Curtis DeGasperi (206) 477-4677

Last Updated March 25, 2016

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YSI 6600 V2 EDS Sensor Specifications

Sensor	Range	Resolution	Accuracy
Temperature (C)	-5 to 50	0.01	+/- 0.15
Conductivity (mS/cm)	0 to 100	0.001 to 0.1	+/- 0.5% of reading
Depth (m)	0 to 61	0.001	+/- 0.12
Dissolved Oxygen (mg/L)	0 to 50	0.01	+/- 0.1
Turbidity (NTU)	0 to 1,000	0.1	0.3
pH	0 to 14	0.01	+/- 0.2
Chlorophyll (ug/L)	0 to 400	0.1	Detection Limit – 0.1

Quality Control

- Annual
  - Temperature Verification using in-Situ Seabird CTD
- Monthly
  - Pre-deployment in-house pH, dissolved oxygen, turbidity, chlorophyll and depth calibration and check standards.
  - Post-deployment end checks of all parameters.

QC Data Entry Page

Enter End Check Data - Windows Internet Explorer

http://green.kingcounty.gov/lake-buoy/DataEntry/EndCheck.aspx

File Edit View Favorites Tools Help

Enter End Check Data

- Historical Profile Plot
- Historical Contour Plot
- View or Download Data
- Data Quality Control
- Buoy Specifications
- Disclaimer
- About This Site

Other Links

- Environmental Monitoring
- Lake Stewardship
- Major Lakes

If you have question on this site, please contact Curtis DeGasperi 206-684-1268.

Data manager can log in, or change password.

					Value	True Value	Value	Value	True Value	Check Value	Value	Check Value	Check Value	Value	Co
Select	Sammamish	C3PO	8/13/2009 12:00:00 PM	9/15/2009 10:00:00 AM	100.00	74.00	6.86	10.00	11.60	101.30	73.00	6.95	11.40	11.20	-5.
Select	Washington	Boba Phet	8/10/2009 2:00:00 PM	9/15/2009 8:30:00 AM	100.00	74.00	6.86	10.00	11.60	98.90	74.00	6.93	11.90	11.40	2.8
Select	Sammamish	Jabba The Hut	7/14/2009 8:30:00 AM	8/13/2009 12:00:00 PM	100.00	74.00	6.86	10.00	11.30	99.90	72.00	7.03	10.40	15.10	-9.
Select	Washington	WWW	7/13/2009 11:00:00 AM	8/10/2009 2:00:00 PM	100.00	74.00	6.86	10.00	11.20	101.30	73.00	6.96	9.90	14.80	-14
Select	Sammamish	C3PO	6/9/2009 11:45:00 AM	7/14/2009 8:30:00 AM	100.00	73.90	6.86	10.00	11.70	100.20	76.00	7.01	8.30	12.10	0.1

1 2 3 4 5 6 7 8 9 10 ...

Please enter date in the formate of mm/dd/yyyy hh:mm:ss AM/PM format, in the range of 1/1/1900 and 6/6/2079.

Buoy:	Sammamish	**Sonde:**	
Installation Date:		**Extraction Date:**	
Lab End Check Date:		**Analyst:**	
DO true Value:		**DO End Check Value:**	
Conductivity true Value:		**Conductivity End Check Value:**	
pH true Value:		**pH End Check Value:**	
Turbidity true Value:		**Turbidity End Check Value:**	
Chlorophyll true Value:		**Chlorophyll End Check Value:**	
pH Calibration Constant:		**Override DO End Check:**	No
Override Conductivity End Check:	No	**Override pH End Check:**	No
Override Turbidity End Check:	No	**Override Chloro End Check:**	No
Override Temperature End Check:	No	**Comment:**	

Insert Cancel

Updated: April 14, 2009

Internet 100%

30 Items This folder is up to date. Connected

start Inbox - Microsoft Out... LakeBuoys Microsoft PowerPoint ... Enter End Check Dat... 8:46 AM

Buoy Sonde Standard Operating Procedures

Parameter Range Check Values

The parameter range check is a quality control step that helps to identify data that are outside of the range expected for that parameter. Parameters outside of their expected ranges are flagged. It is possible that the values reported as outside of the expected range are correct, but further evaluation of related data (e.g., weather) should be reviewed to establish that conditions were consistent with the flagged data.

Parameter	Minimum	Maximum
Air Temperature	-10.00 (°C)	35.00 (°C)
Atmosphere Pressure	900.00 (mb)	1100.00 (mb)
Battery	11.00 (V)	15.00 (V)
Chlorophyll	-2.00 (µg/l)	50.00 (µg/l)
Depth	0.00 (m)	65.00 (m)
DO Concentration	0.01 (mg/l)	22.00 (mg/l)
DO Percent Saturation	0.10 (%)	190.00 (%)
pH	4.00	10.00
Relative Humidity	10.00 (%)	100.00 (%)
Solar Radiation	0.00 (watts/sq meter)	1000.00 (watts/sq meter)
Specific Conductance	20.00 (µS/cm)	200.00 (µS/cm)
Temperature	0.00 (°C)	30.00 (°C)
Turbidity	-5.00 (NTU)	50.00 (NTU)
Wind Direction	0.00 (degrees)	360.00 (degrees)
Wind Speed	0.00 (m/sec)	30.00 (m/sec)

End Check Condition

The end check is a quality control step that helps to ensure that the sensors remained within calibration acceptance limits throughout the deployment period. Once the sonde is back in the lab all the sensors are tested using check standards of known value. If end check values are outside of the accepted limits for individual sensors, data for that deployment period may be flagged.

Parameter	Good	Fair	Poor
Chlorophyll	±15 percent	±25 percent	>±25 percent
DO	±5 percent	±10 percent	>±10 percent
pH	±0.15 units	±0.20 units	>±0.20 units
Specific Conductance	±5 percent	±10 percent	>±10 percent
Turbidity	±15 percent	±25 percent	>±25 percent

King County Lake Monitoring Buoys

You're in: Lake Buoy > View or Download Data

PROVISIONAL DATA SUBJECT TO REVISION

Data Type: Profile (entire depth)
Buoy: Sammamish (includes RUSS S. SAMM)
Year: 2009
Start Month: 1
End Month: 1

Color Legend
- Parameters out-of-range or End check fails
- End check condition poor
- End check condition fair
- End check condition unavailable

Available range is from 7/27/2000 to 11/9/2009

View | Download

Date	Depth (m)	Temperature (°C)	Specific Conductance (µS/cm)	DO Concentration (mg/l)	DO Saturation (%)	pH	Chlorophyll (µg/l)	Turbidity (NTU)	Provisional	End Check Condition
1/14/2009 12:28:00 PM	0.997	6.95	106.00	9.54	78.50	7.95	-4.70	3.90	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:30:00 PM	1.998	6.95	106.00	9.53	78.50	7.98	2.10	4.10	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:32:00 PM	3.040	6.92	106.00	9.53	78.40	7.98	1.80	3.90	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:34:00 PM	4.049	6.91	106.00	9.53	78.30	7.98	2.30	4.10	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:36:00 PM	5.010	6.90	106.00	9.51	78.20	7.98	1.10	3.90	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:38:00 PM	6.076	6.87	106.00	9.48	77.90	7.98	1.10	4.30	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:40:00 PM	6.950	6.86	106.00	9.47	77.70	7.97	2.10	4.20	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:42:00 PM	8.060	6.86	106.00	9.45	77.60	7.98	0.90	3.90	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:44:00 PM	9.060	6.86	106.00	9.44	77.50	7.97	1.40	4.10	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:46:00 PM	10.050	6.85	106.00	9.44	77.50	7.97	0.10	4.40	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:48:00 PM	11.050	6.85	106.00	9.42	77.30	7.96	0.50	4.40	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:50:00 PM	11.910	6.84	106.00	9.40	77.10	7.96	0.40	4.30	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:52:00 PM	12.950	6.84	106.00	9.38	77.00	7.97	0.50	4.20	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:54:00 PM	14.030	6.83	106.00	9.36	76.80	7.96	1.20	4.30	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:56:00 PM	14.980	6.83	106.00	9.35	76.70	7.97	0.90	4.20	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 12:58:00 PM	15.990	6.82	106.00	9.34	76.60	7.96	1.70	4.40	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 1:00:00 PM	17.020	6.82	106.00	9.32	76.40	7.96	-0.20	4.60	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 1:02:00 PM	18.040	6.82	106.00	9.32	76.40	7.96	-0.90	4.50	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 1:04:00 PM	18.990	6.81	106.00	9.30	76.30	7.96	0.50	5.10	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 1:06:00 PM	20.040	6.81	106.00	9.30	76.30	7.96	1.20	5.10	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 1:08:00 PM	21.060	6.80	106.00	9.29	76.10	7.95	1.10	5.20	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 1:10:00 PM	22.070	6.79	100.00	9.20	75.40	7.87	2.70	20.00	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 1:12:00 PM	23.050	6.79	99.00	9.19	75.30	7.86	3.00	21.10	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 1:14:00 PM	24.010	6.79	95.00	9.13	74.80	7.81	3.20	33.60	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 1:16:00 PM	25.020	6.87	93.00	9.00	73.90	7.76	3.60	50.80	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 4:03:00 PM	1.080	6.92	106.00	9.54	78.40	8.01	2.00	3.80	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 4:05:00 PM	1.955	6.91	106.00	9.53	78.40	8.01	1.10	3.90	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 4:07:00 PM	2.933	6.91	106.00	9.53	78.40	8.01	1.60	4.00	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/14/2009 4:51:00 PM	25.030	6.87	97.00	8.86	72.70	7.81	2.20	34.40	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G
1/15/2009 12:03:00 AM	1.043	6.82	106.00	9.44	77.40	8.01	1.60	4.20	No	DO (Good); Chlorophyll (Good); Conductivity (Good); Turbidity (G

Water and land services
Lakes

Lake buoy data
- Latest Weather
- Latest Profiles
- Historical Profile Plot
- Historical Contour Plot
- View or Download Data
- Data Quality Control
- Buoy Specifications
- Disclaimer
- About This Site
- Data Entry

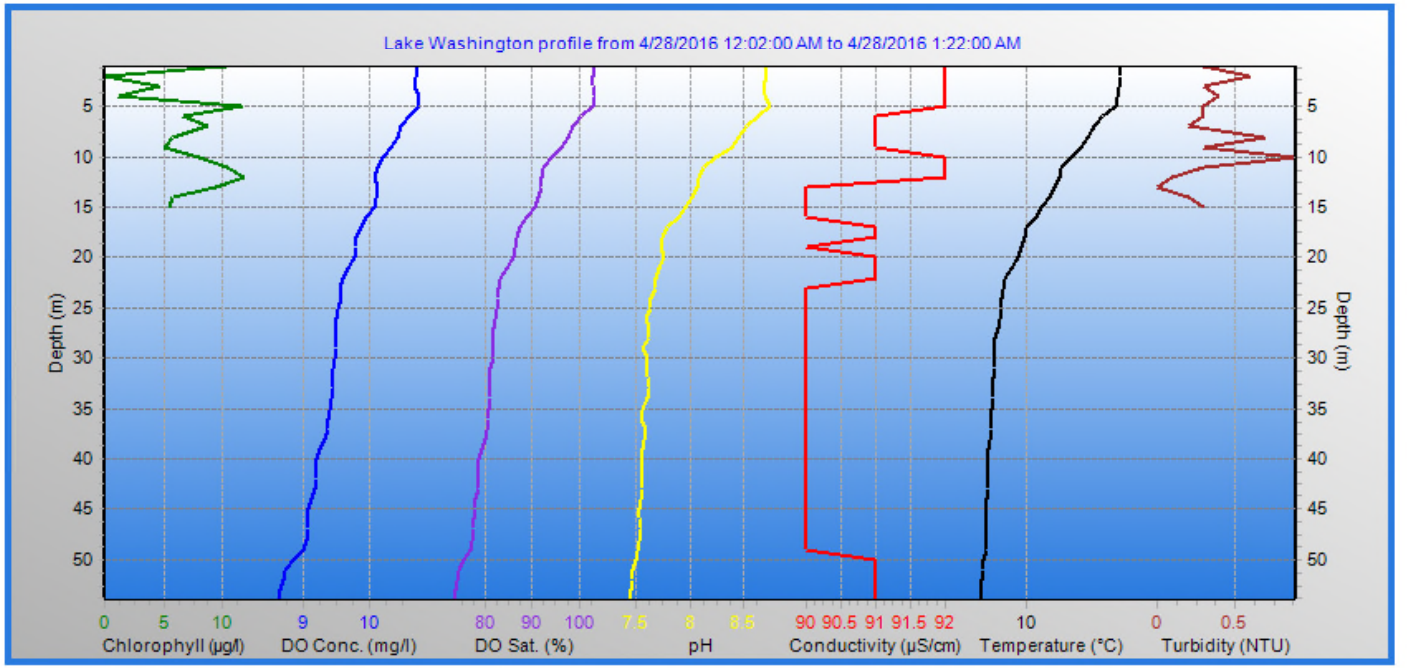
Home » Services » Environment » Water and land services » Lakes » Lake buoy data » Historical Profile Plot

Historical Profile Plot

PROVISIONAL DATA SUBJECT TO REVISION

Buoy	Date	Time	
Washington	4/28/2016	1:22	Plot

Available range is from 1/10/2008 to 4/28/2016



Note: Parameters out-of-range are excluded from the graph. If end check fails for a value or the value is categorized as poor, those values are excluded from the graph. The end check process is explained here. Range check is explained here.

Water and land services
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Home » Services » Environment » Water and land services » Lakes » Lake buoy data » Historical Contour Plot

Historical Contour Plot

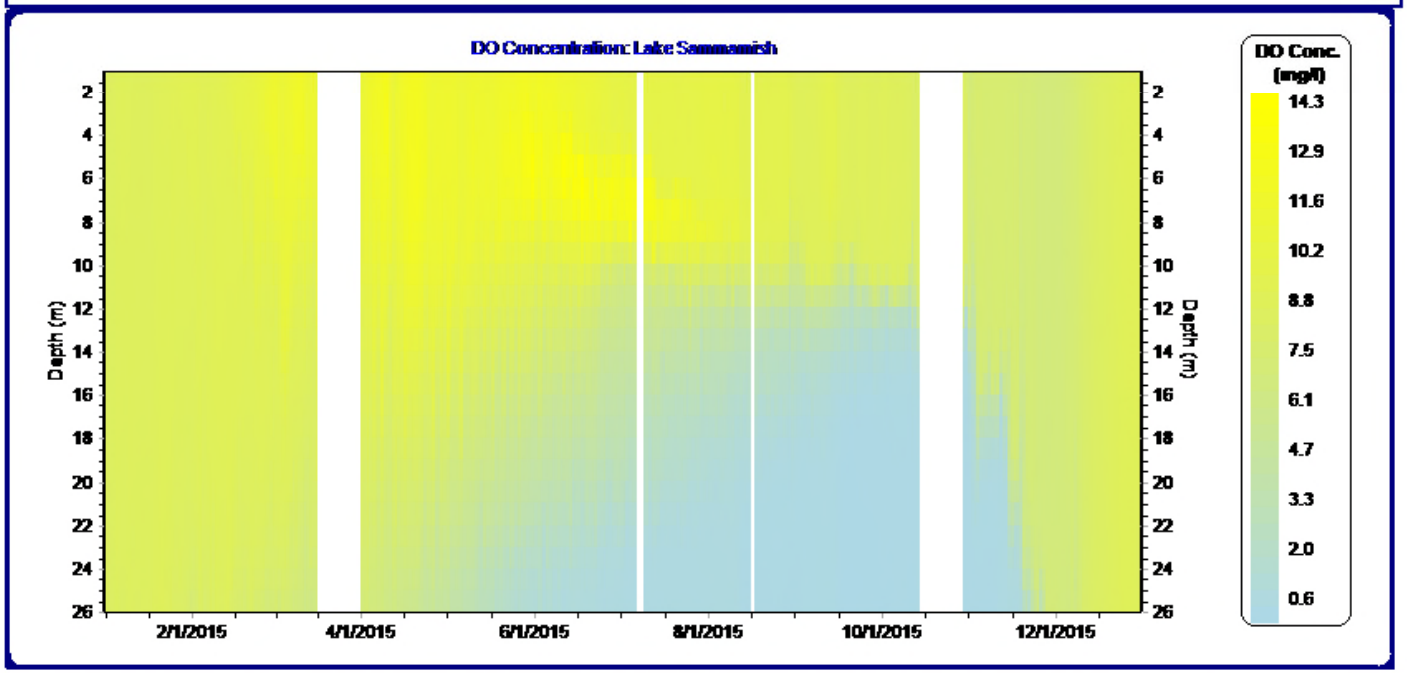
PROVISIONAL DATA SUBJECT TO REVISION

Buoy: Sammamish (includes RUSS S. SAMM)

Parameter: DO Concentration

Year: 2015

Plot

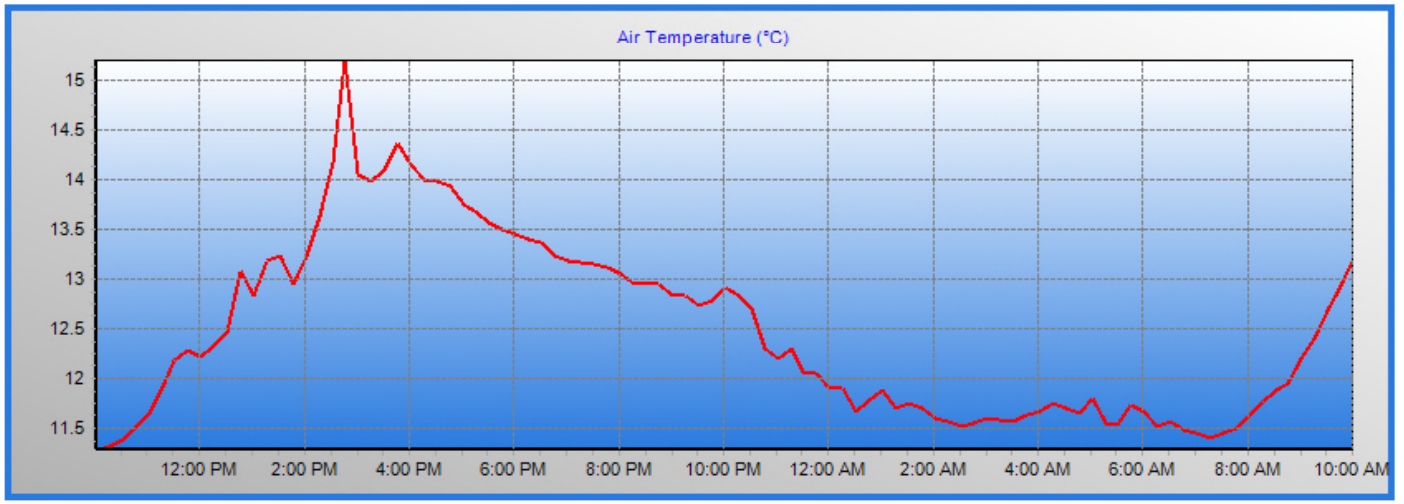


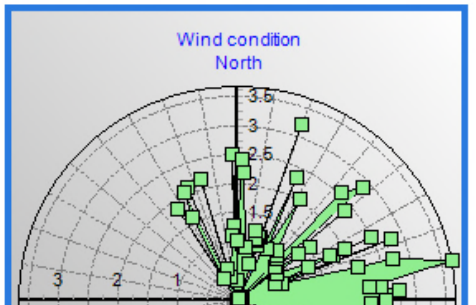
Note: Parameters out-of-range are excluded from the graph. If end check fails for a value or the value is categorized as poor, those values are excluded from the graph. The end check process is explained here. Range check is explained here.

Washington Weather

PROVISIONAL DATA SUBJECT TO REVISION

It is currently daylight savings time. Buoy data are collected in Pacific Standard Time.
Add 1 hour to times shown in the graphs below for local (Pacific Daylight) time.
Data shown are from the latest weather data collected in the 24-hour period since the last measurement downloaded at 4/28/2016 11:02 AM PDT





LakeAnalyzer

Environmental Modelling & Software 26 (2011) 1325–1336

Contents lists available at ScienceDirect

Environmental Modelling & Software

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

Derivation of lake mixing and stratification indices from high-resolution lake buoy data

Jordan S. Read [a], David P. Hamilton [b,*], Ian D. Jones [c], Kohji Muraoka [b], Luke A. Winslow [d], Ryan Kroiss [d], Chin H. Wu [a], Evelyn Gaiser [e]

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Mixing
Lake number
Wedderburn number
Schmidt stability
Thermocline depth
Software
Instrumented buoy
GLEON

ABSTRACT

Lake Analyzer is a numerical code coupled with supporting visualization tools for determining indices of mixing and stratification that are critical to the biogeochemical cycles of lakes and reservoirs. Stability indices, including Lake Number, Wedderburn Number, Schmidt Stability, and thermocline depth are calculated according to established literature definitions and returned to the user in a time series format. The program was created for the analysis of high-frequency data collected from instrumented lake buoys, in support of the emerging field of aquatic sensor network science. Available outputs for the Lake Analyzer program are: water temperature (error-checked and/or down-sampled), wind speed (error-checked and/or down-sampled), metalimnion extent (top and bottom), thermocline depth, friction velocity, Lake Number, Wedderburn Number, Schmidt Stability, mode-1 vertical seiche period, and Brunt-Väisälä buoyancy frequency. Secondary outputs for several of these indices delineate the parent thermocline depth (seasonal thermocline) from the shallower secondary or diurnal thermocline. Lake Analyzer provides a program suite and best practices for the comparison of mixing and stratification indices in lakes across gradients of climate, hydro-physiography, and time, and enables a more detailed understanding of the resulting biogeochemical transformations at different spatial and temporal scales.

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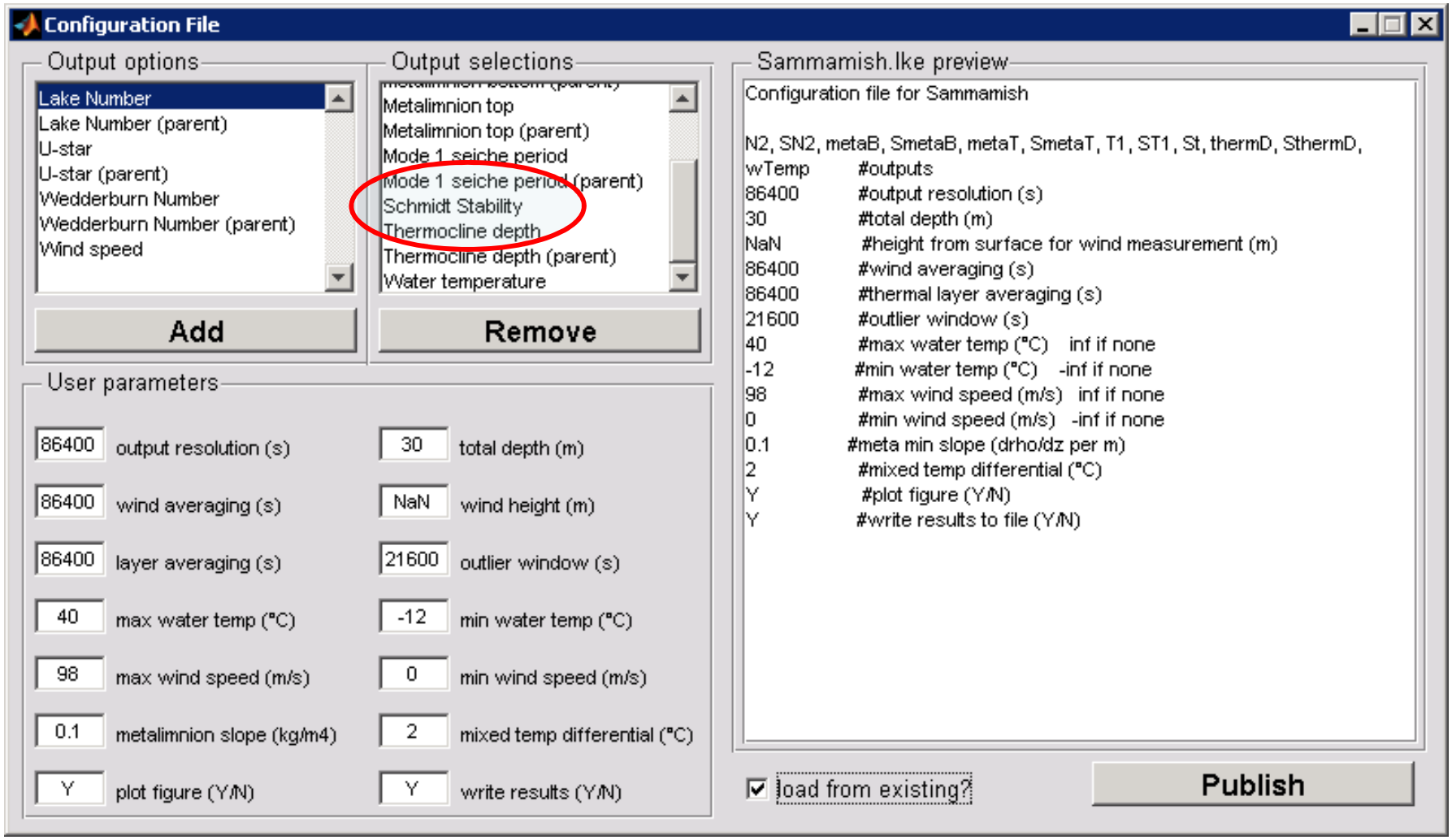
global lake ecological observatory network

Read JS, DP Hamilton, ID Jones, K Muraoka, LA Winslow, R Kroiss, CH Wu, E Gaiser. 2011. Derivation of lake mixing and stratification indices from high-resolution lake buoy data. Environmental Modelling and Software. 26: 1325-1336.

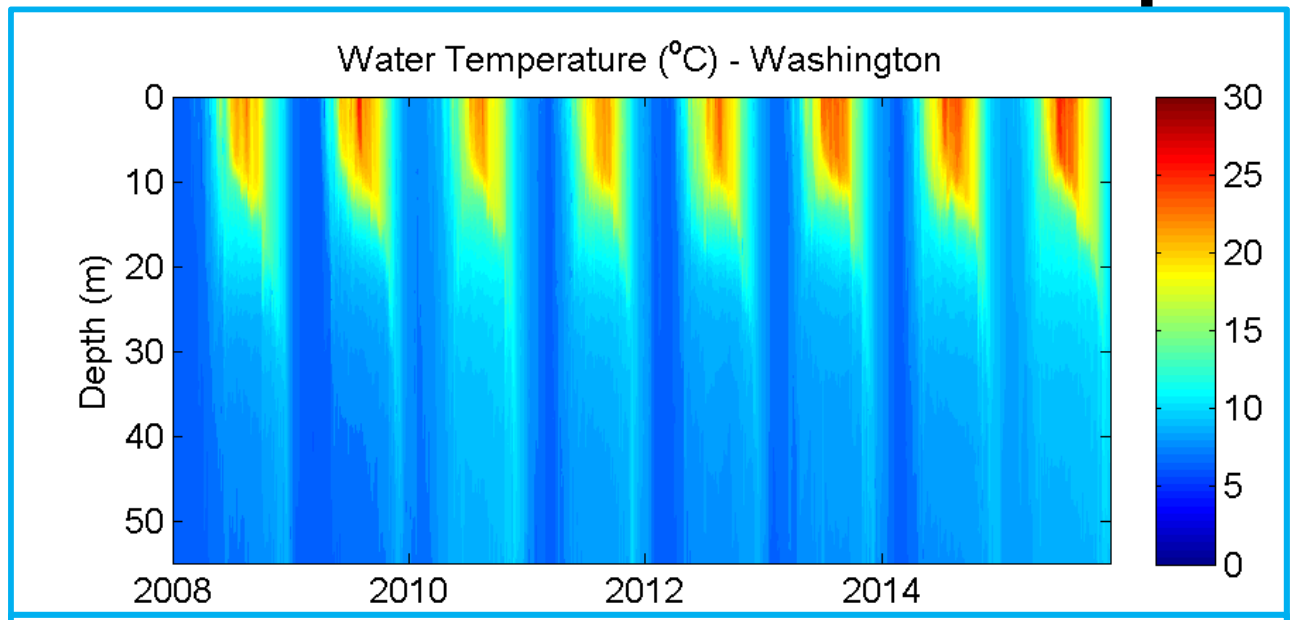
Lake Analyzer



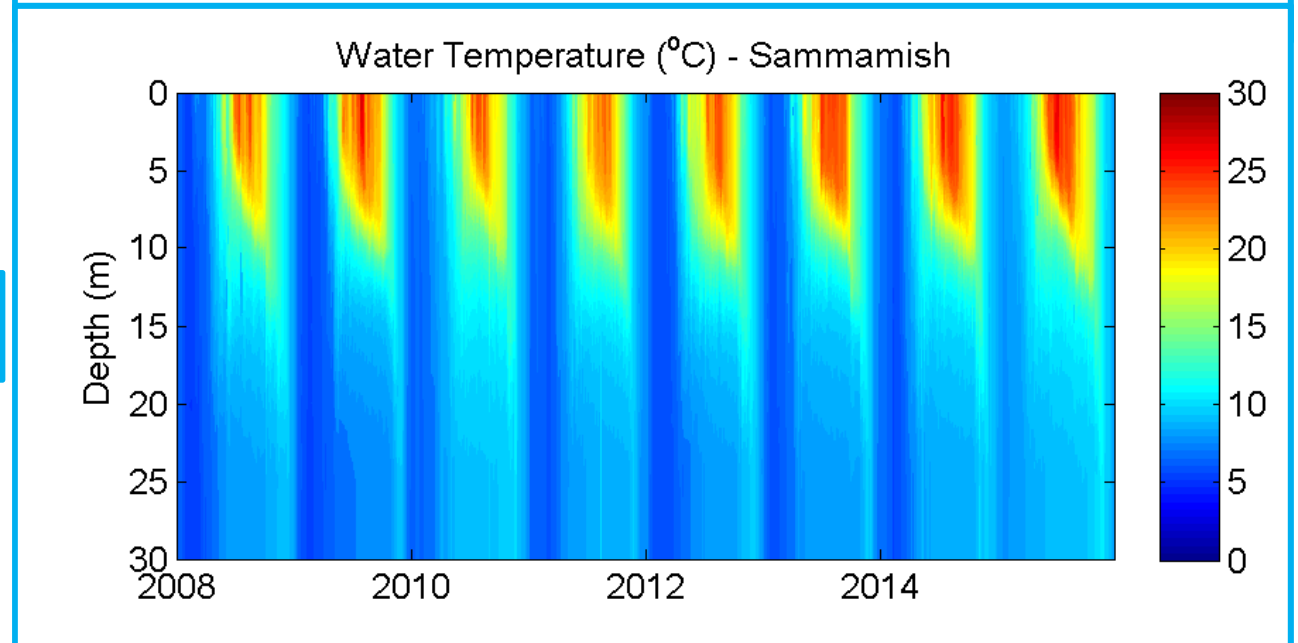
Read JS, DP Hamilton, ID Jones, K Muraoka, LA Winslow, R Kroiss, CH Wu, E Gaiser. 2011. Derivation of lake mixing and stratification indices from high-resolution lake buoy data. Environmental Modelling and Software. 26: 1325-1336.

Lake Analyzer
Temperature color contour plots

Washington

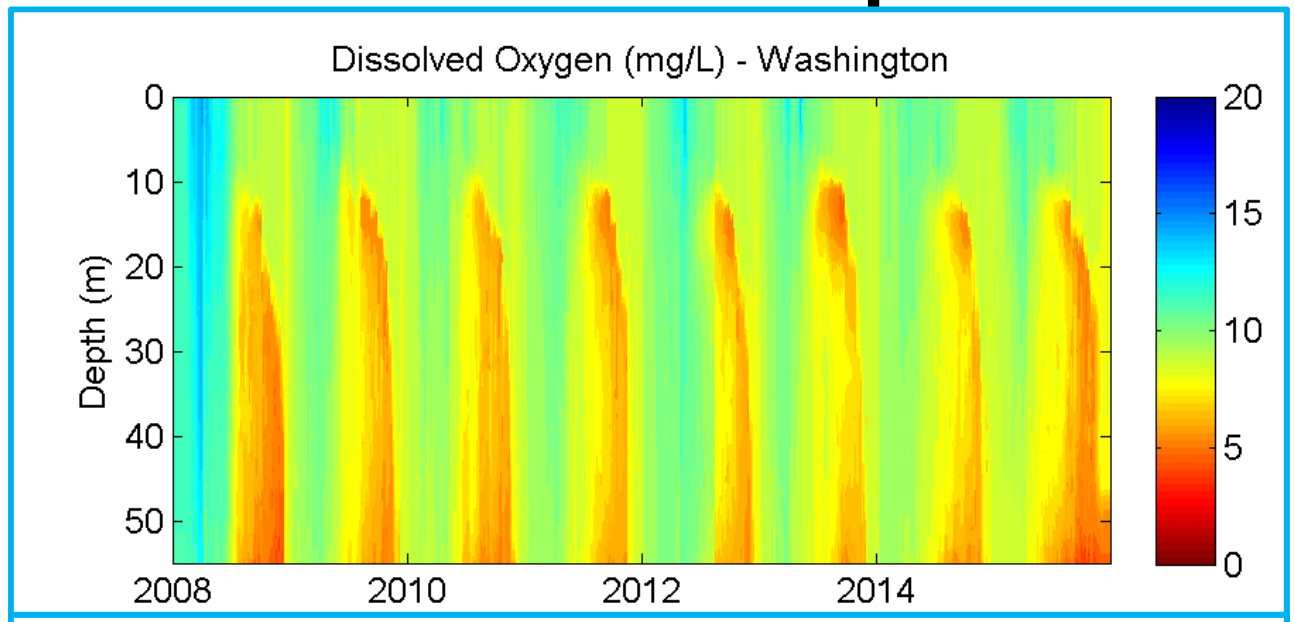


Sammamish

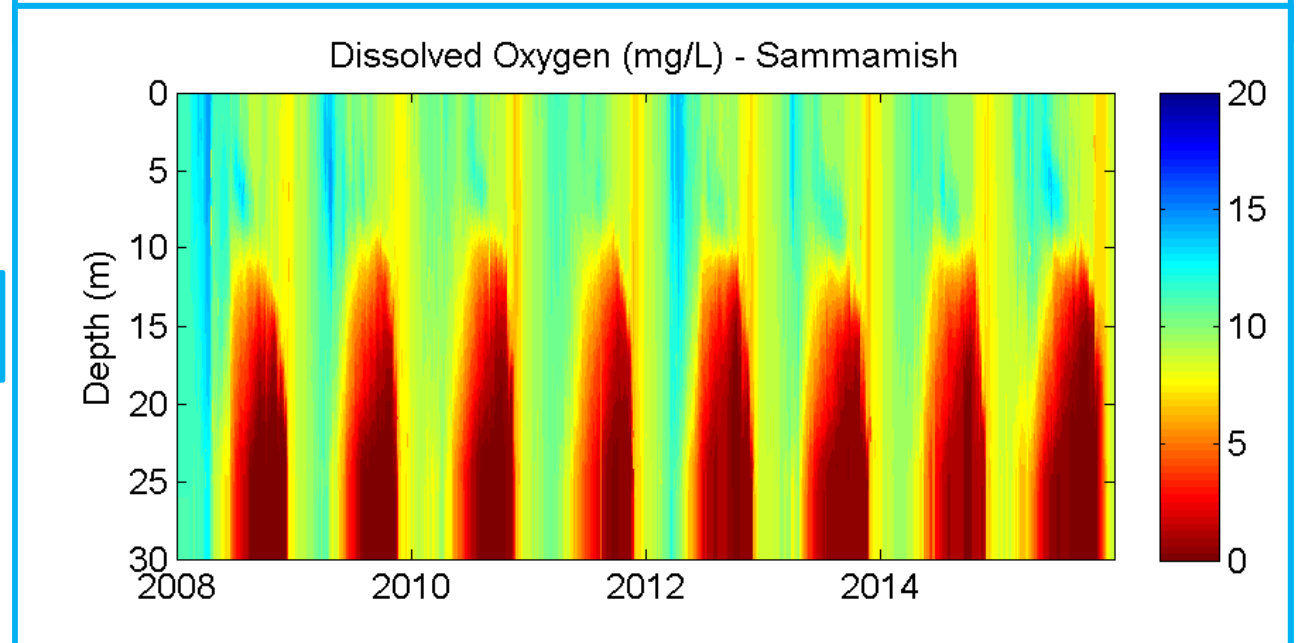


Lake Analyzer
DO color contour plots

Washington



Sammamish



Schmidt's Stability Index

Schmidt (1915, 1928) as modified by Idso (1973)

$$S = A_o^{-1} \sum_{z_0}^{z_m} (z - z_{\bar{p}})(p_z - \bar{p})\, A_z\, \Delta z$$

A_o = Lake surface area (cm^2)

p_z = Density at depth z ($g\ cm^{-3}$)

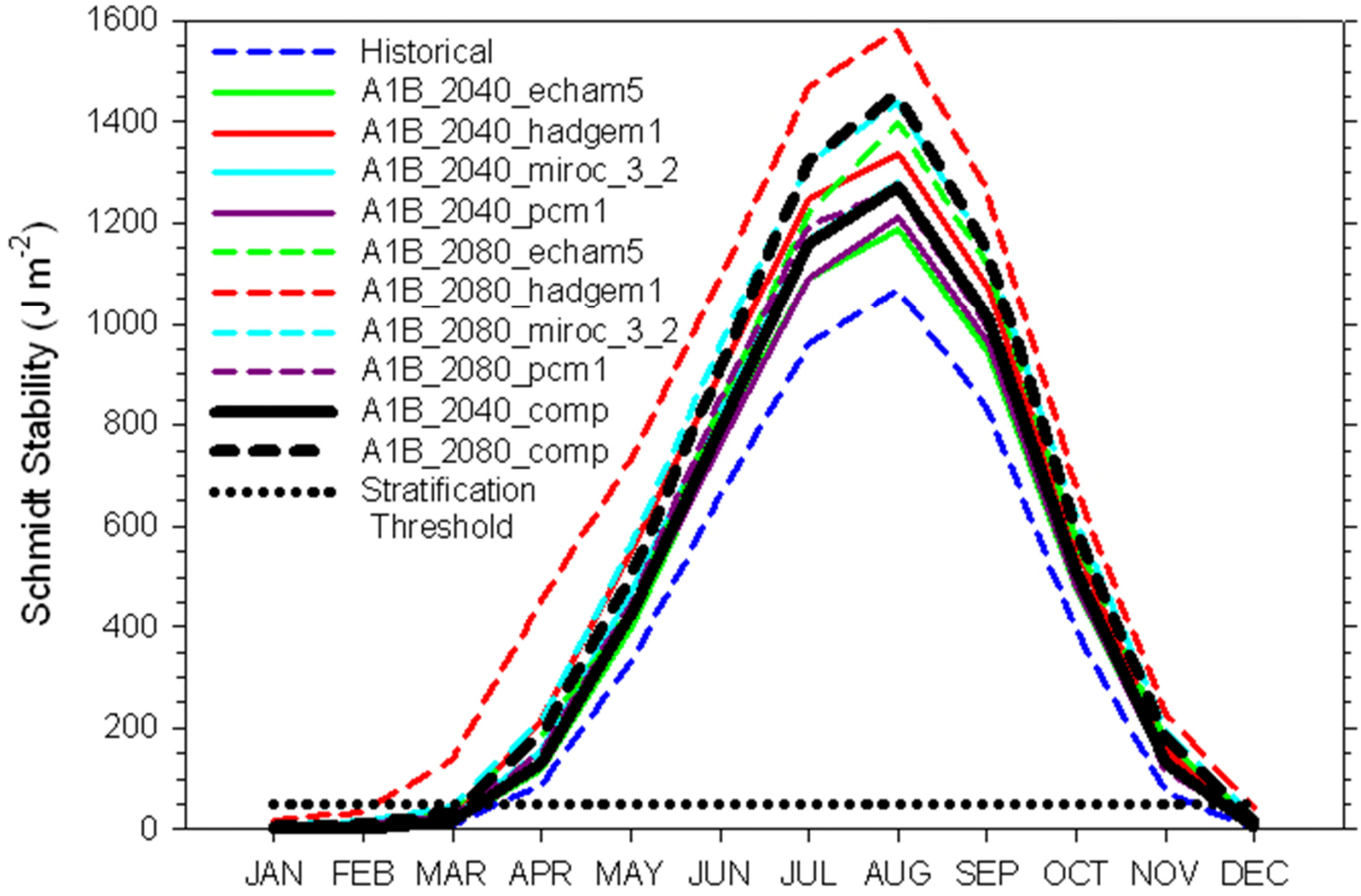
$\bar{p}$ = Mean density ($g\ cm^{-3}$)

z = Depth at measurement point in centimeters

$z_{\bar{p}}$ = Depth in centimeters where mean density is found

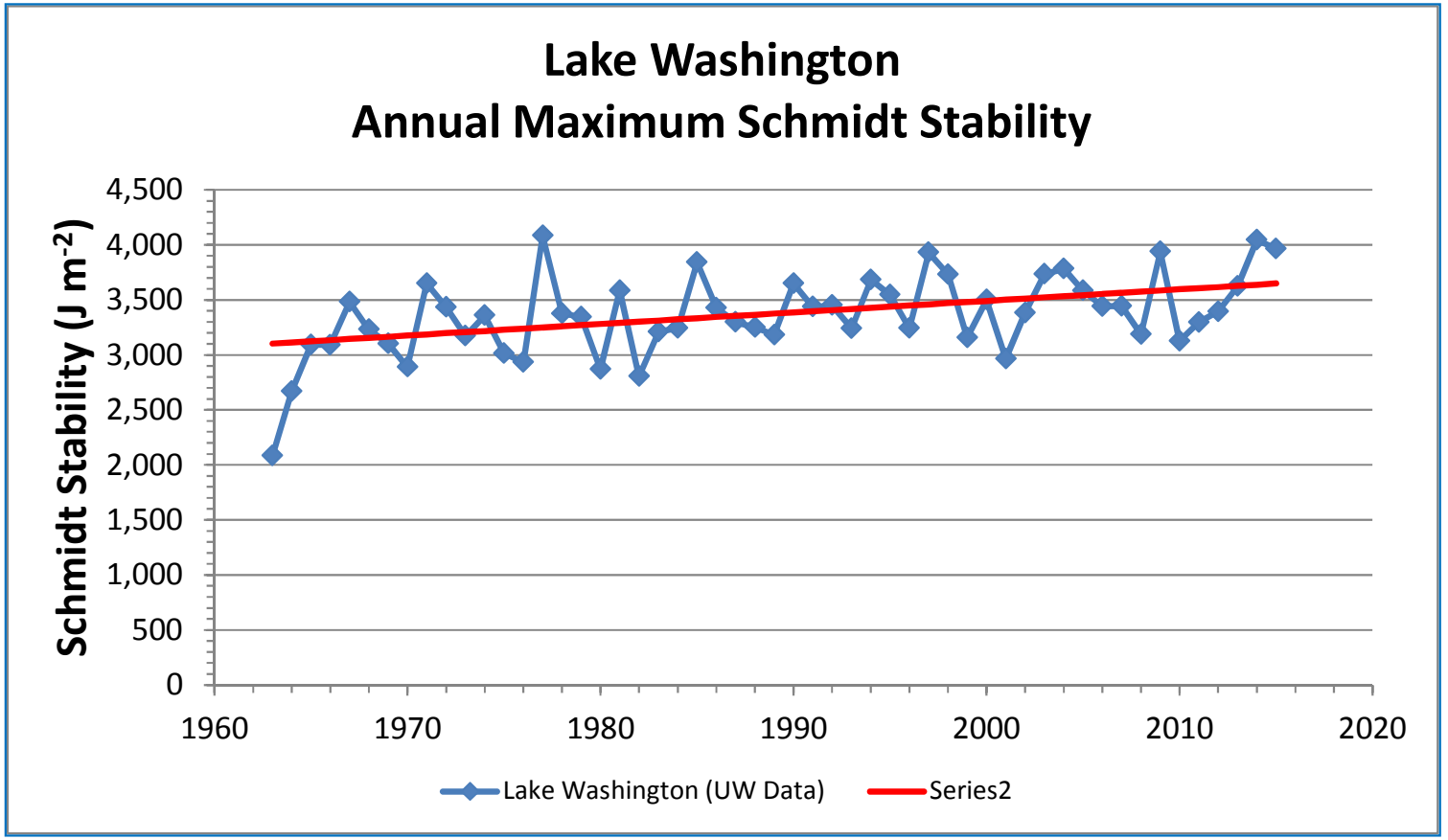
A_z = Area at depth z (cm^2)

Monthly Average Schmidt Stability



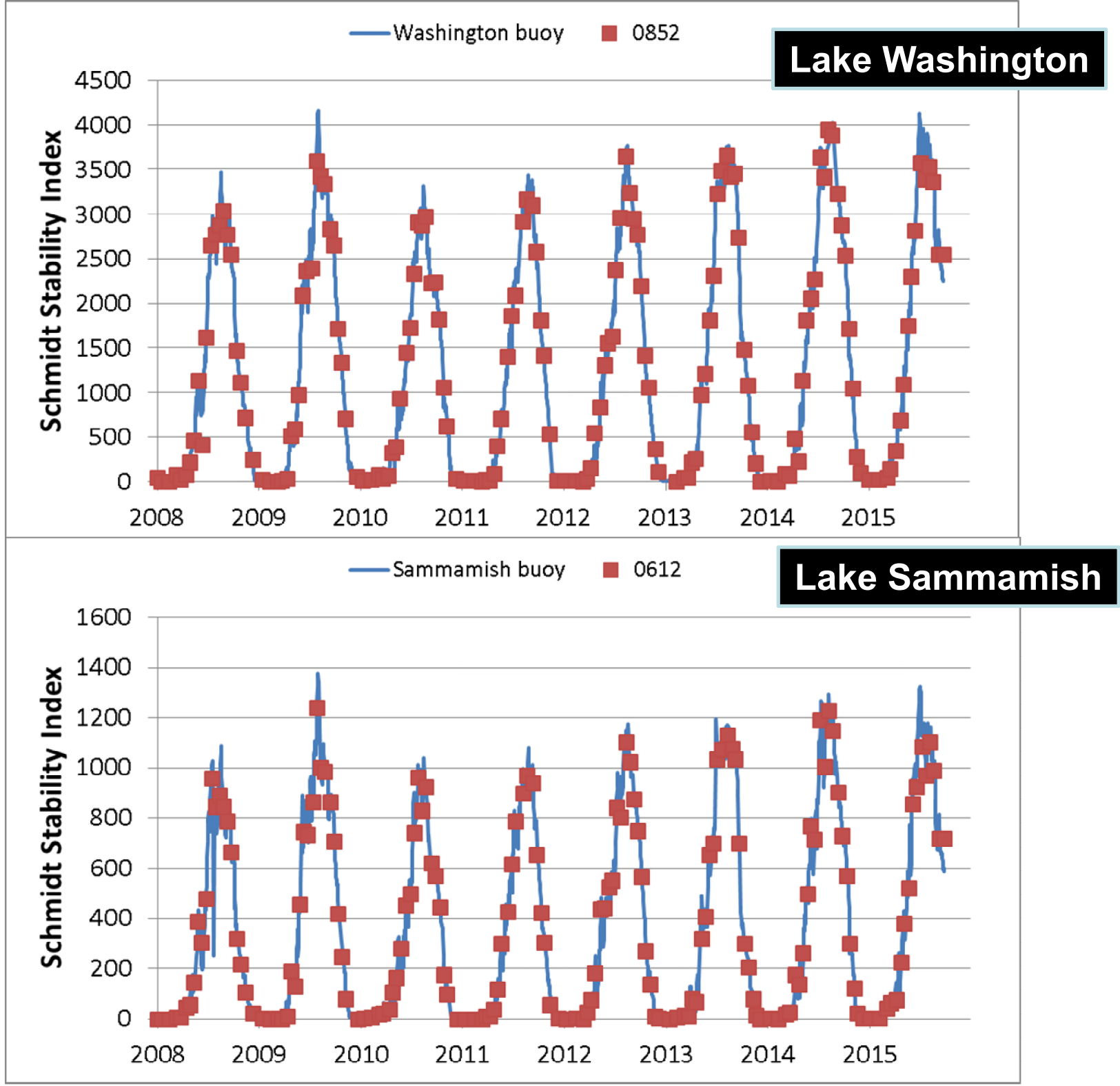
2-D Model

Trend toward increasing lake thermal stability

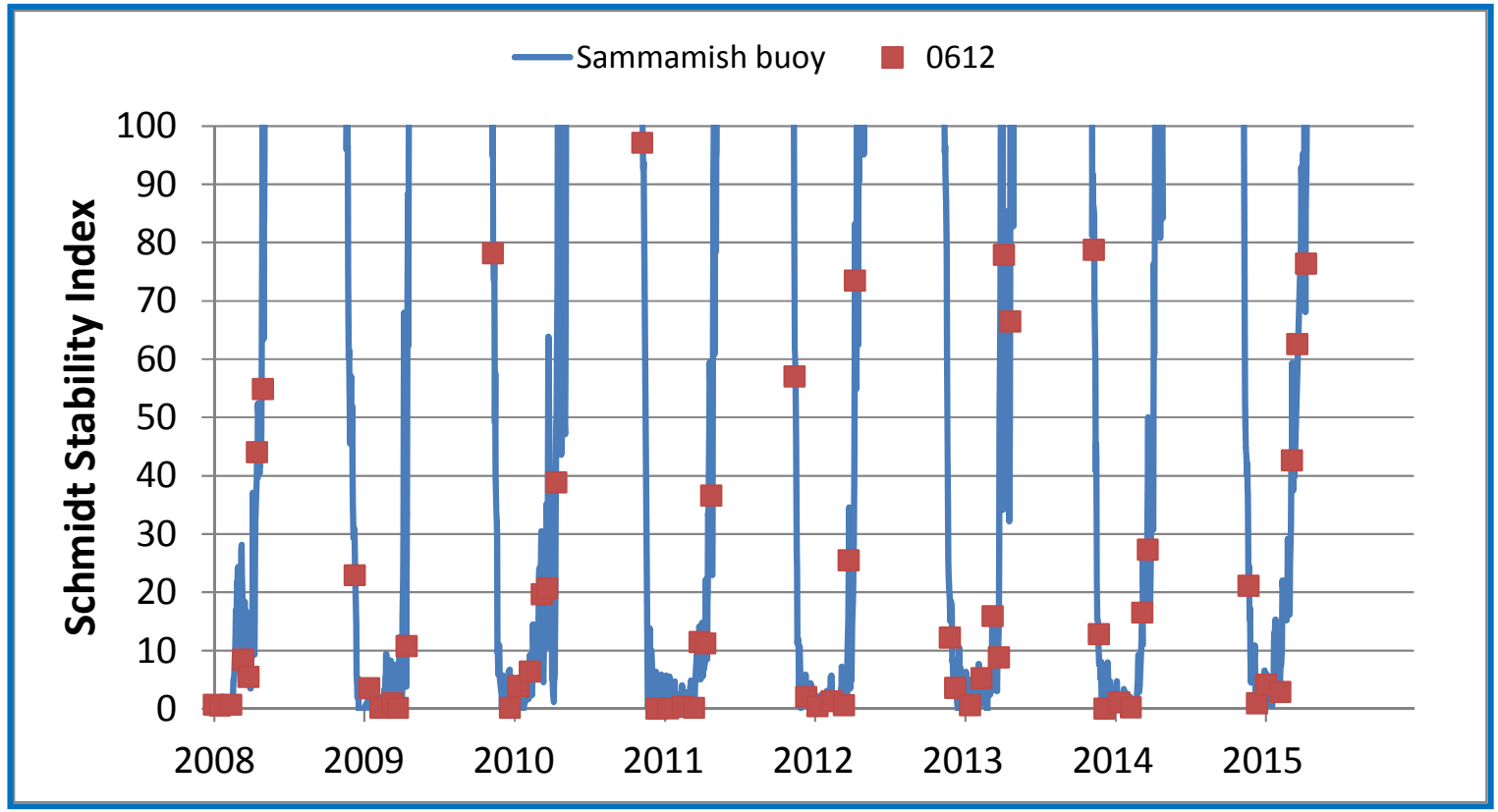


Lake Washington temperature data courtesy of Dr. Daniel Schindler, University of Washington

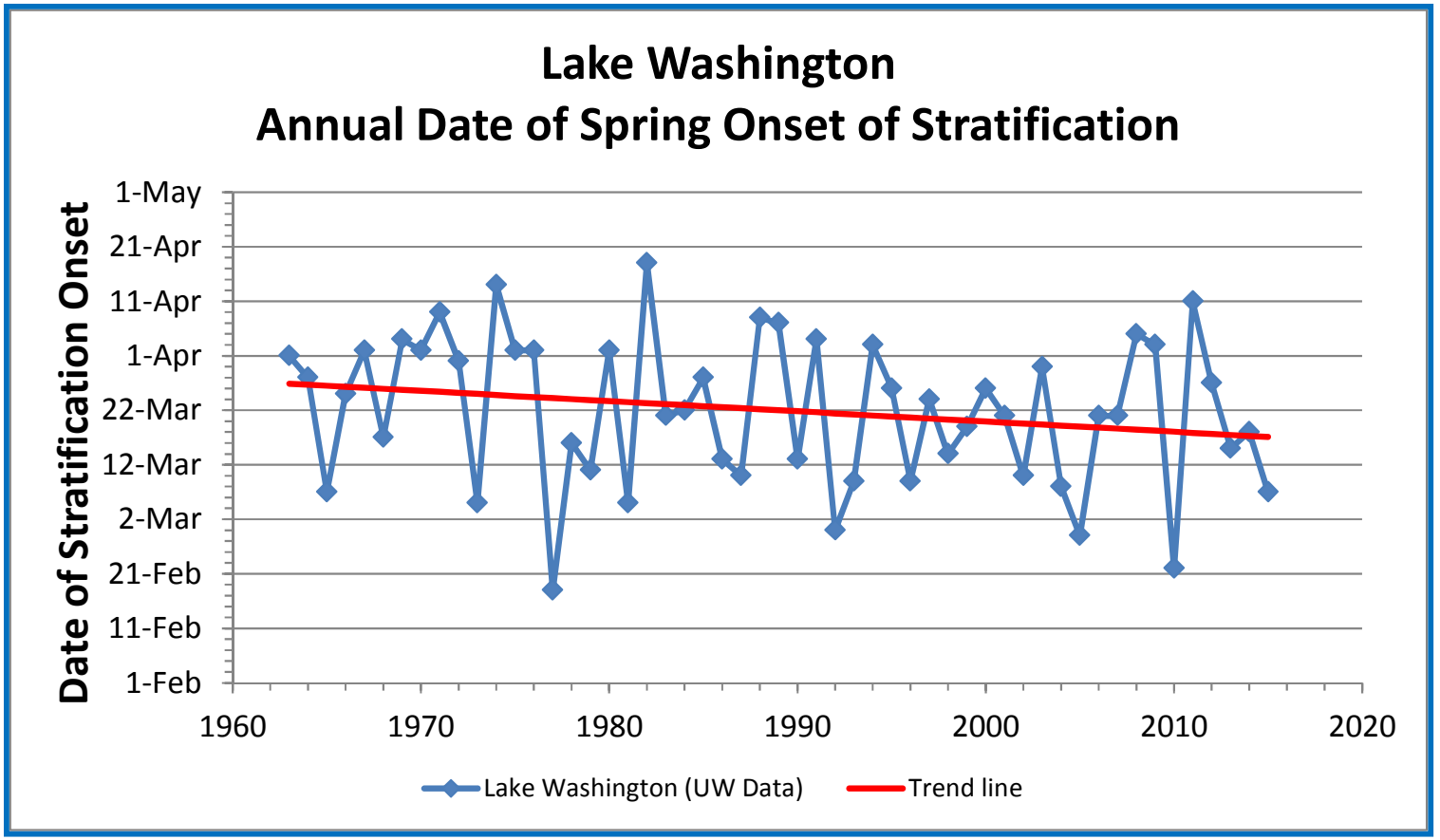
Mann-Kendall p-value = 0.0004


Lake Washington
Washington buoy
0852
Schmidt Stability Index
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2008
2009
2010
2011
2012
2013
2014
2015
Lake Sammamish
Sammamish buoy
0612
Schmidt Stability Index
1600
1400
1200
1000
800
600
400
200
0
2008
2009
2010
2011
2012
2013
2014
2015

Expect high resolution temperature profiling will better capture date of onset of stratification



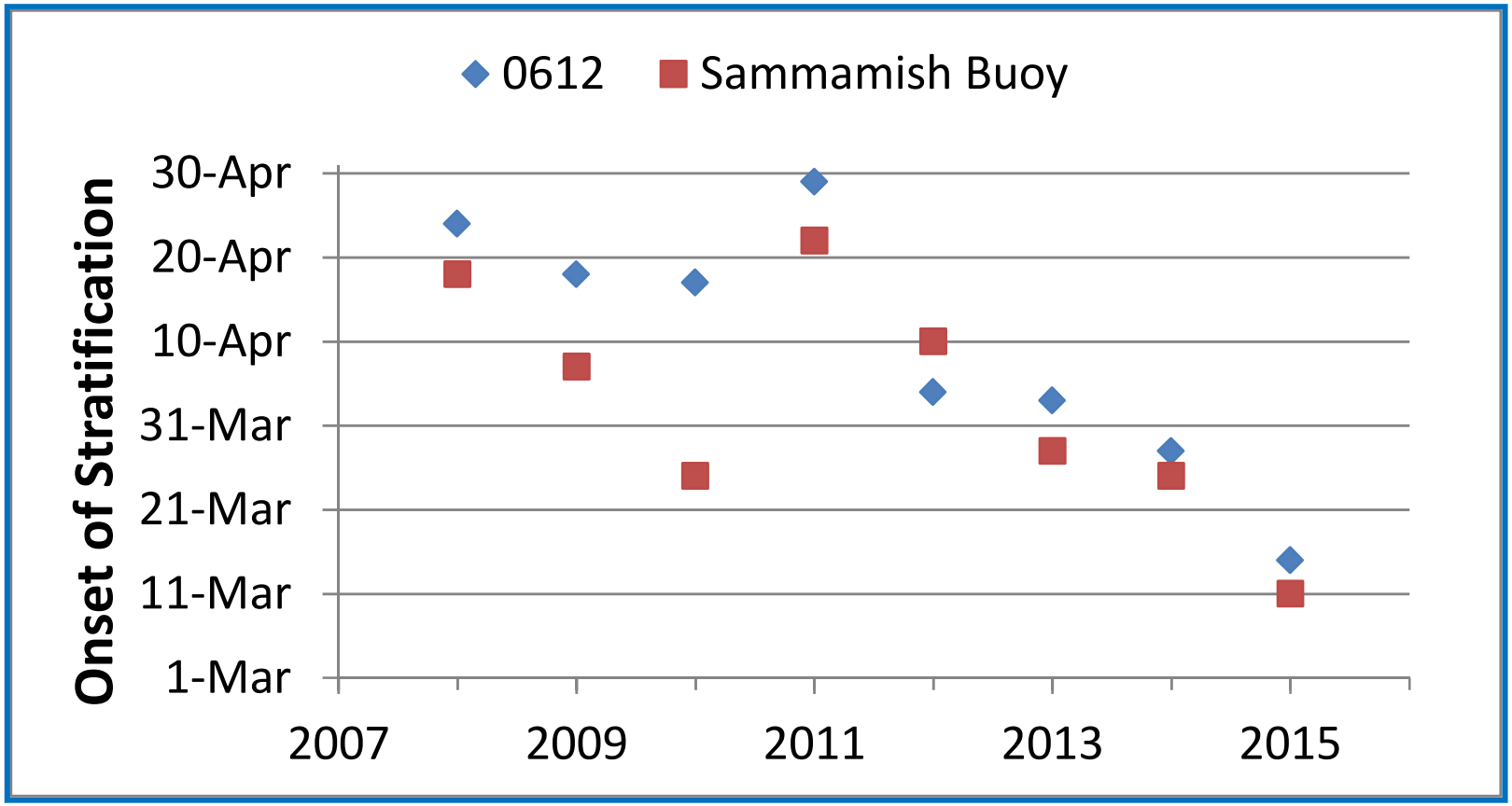
Trend toward earlier onset of stratification



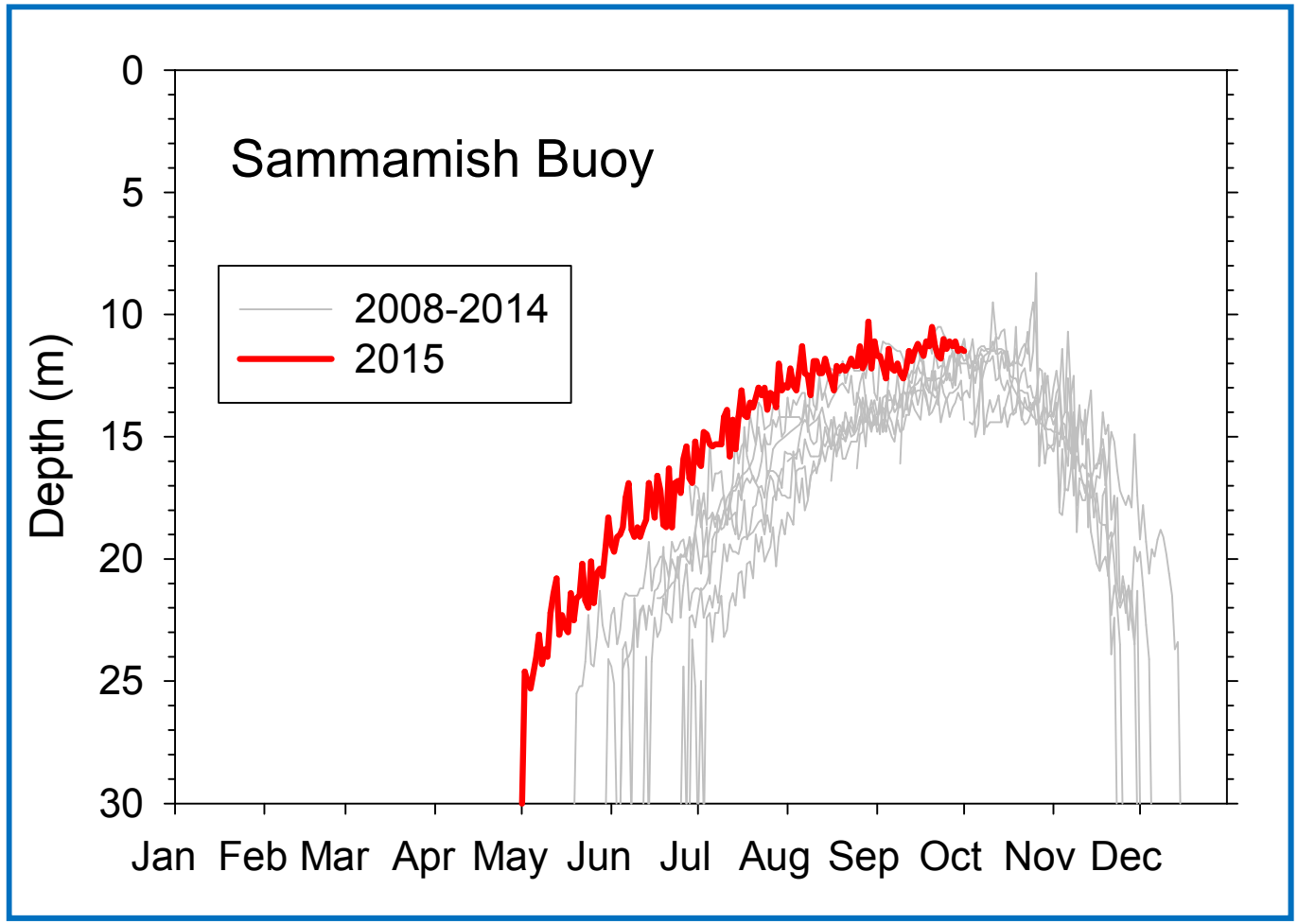
Lake Washington temperature data courtesy of Dr. Daniel Schindler, University of Washington

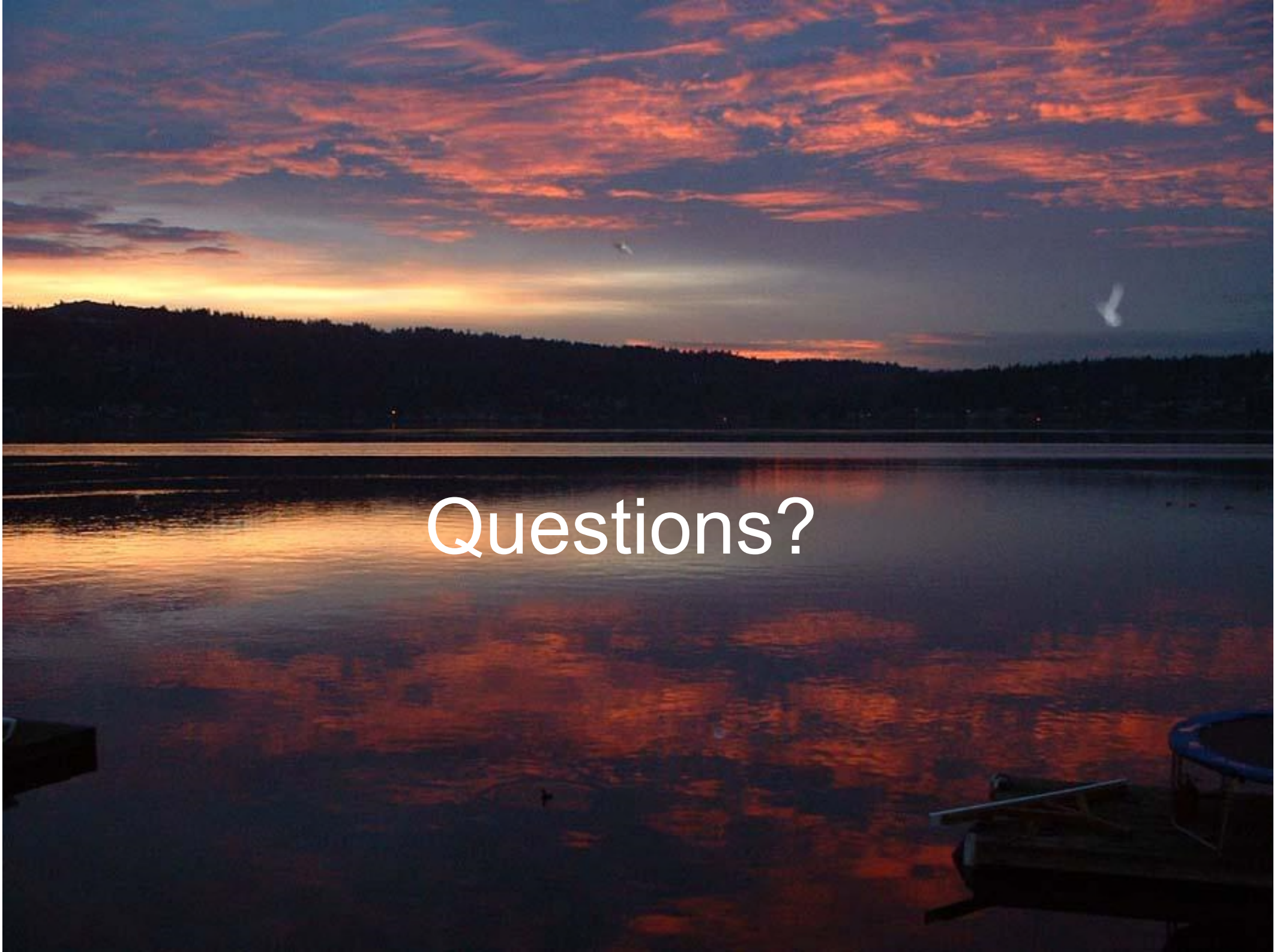
Mann-Kendall p-value = 0.097

Lake Sammamish
Date of Onset of Stratification



Lake Sammamish DO 4 mg/L isopleths




Questions?