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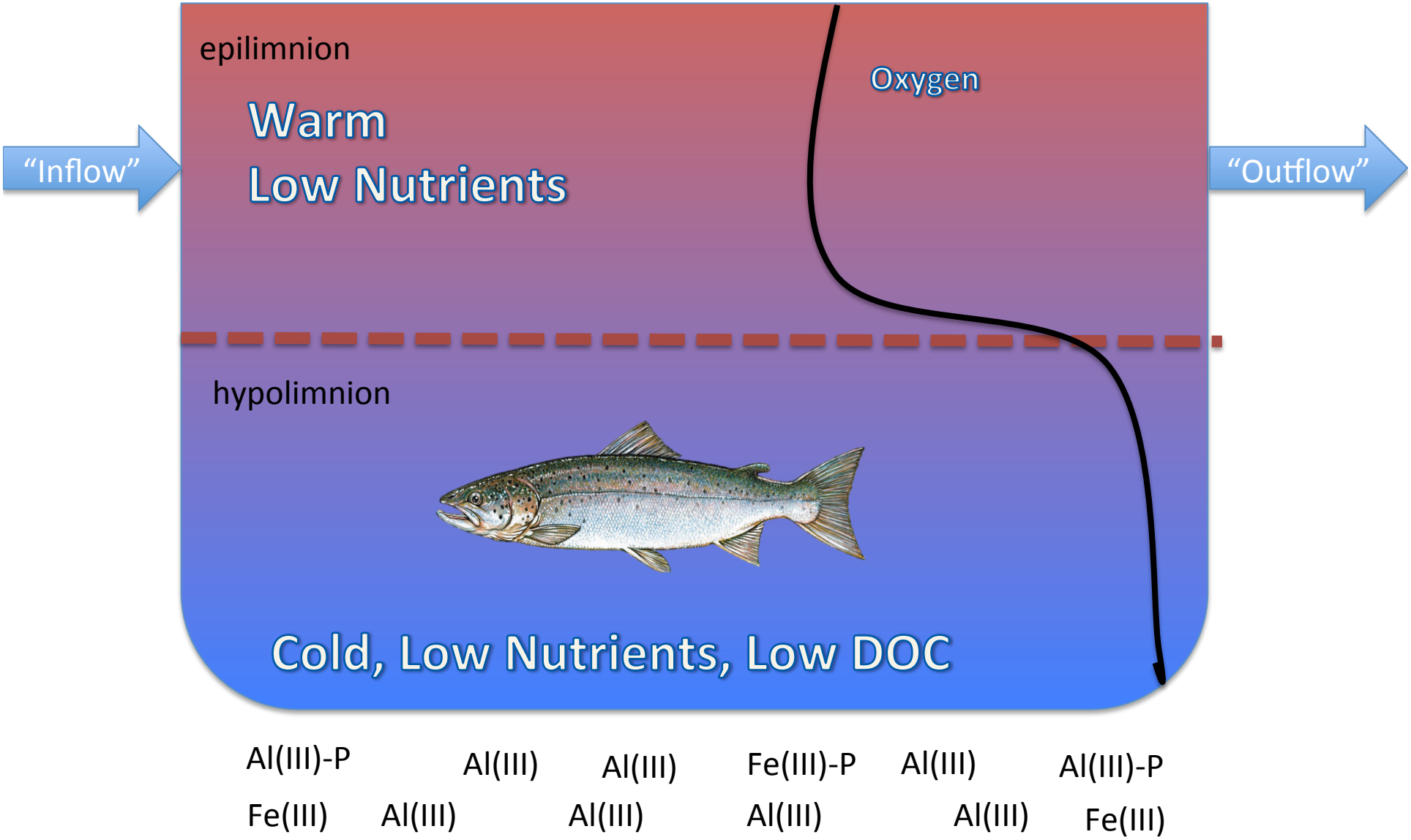
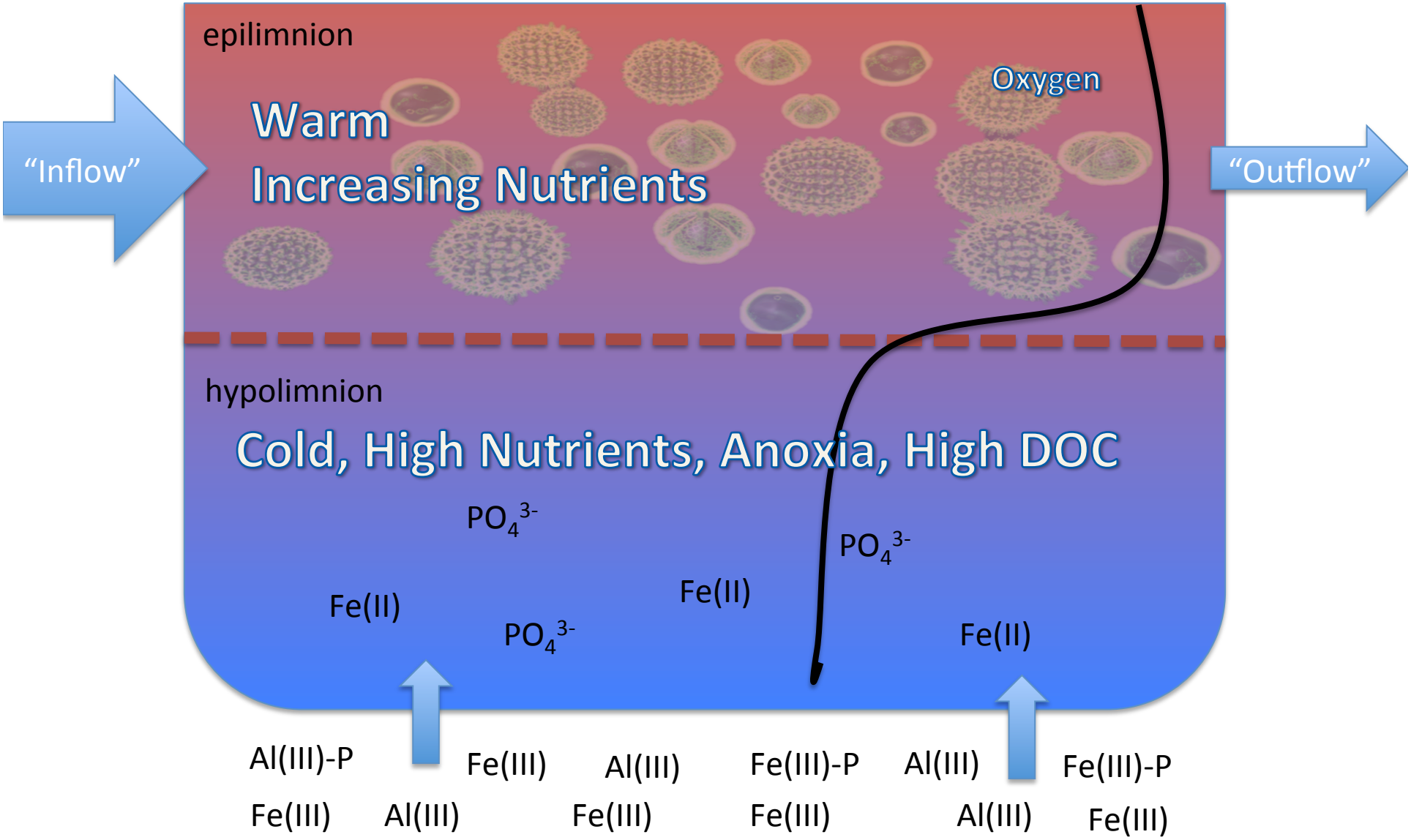
Supported by the National Science Foundation award #EPS-0904155 to Maine EPSCoR at the University of Maine, Colby College, BRCA, and Tom Klingenstein

# Pristine Lake



# Impacted Lake – Understanding the nutrient dynamics informs effective remediation



# Lake Tipping Points have been reached in East Pond and Salmon Lake

# East Pond 2015 – Moderate Fall Bloom

# Belgrade Lakes Project – December Update

## Project Goals

1. Document the current water quality status of each of the Belgrade Lakes. We know that water quality in the lakes is declining. However, we still have gaps in data necessary to determine the most effective remediation strategies.

2. Conduct an educational campaign to make the Belgrade lakes community aware of water quality issues and the plans to address them.

3. Convene and manage a committee made up of representatives from all watershed constituencies to complete a comprehensive water quality improvement action plan.

# Belgrade Lakes Project – December Update

**Water Quality Project Work Flow**

| Task | May | June | July | August | September | October | November | December | January |
|---|---|---|---|---|---|---|---|---|---|
| Weekly Water column profiles | | | | | | | | analysis | |
| Sediment sampling | | | | | | | | analysis | |
| Bi-weekly Plankton Enumeration | | | | | | | | analysis | |
| Weekly Secchi | | | | | | | | | |
| Net Primary Productivity | | | | | | | | | |
| Gloeotrichia | | | | | | | | q-PCR | |
| Dynamic webpage | | | | | | | | | |
| Weather reports | | | | | | | | | |
| Milfoil surveys and remediation | | | | | | | | | |
| East Pond Al "Jar Tests" | | | | | | | | analysis | |
| Assessment of LakeSmart | | | | | | | | | |
| Shoreline assessment | | | | | | | | | |
| Analysis of Data | | | | | | | | lots of analysis | |
| Create Steering Committee | | | | | | | | | |
| Management Plan | | | | | | | | | |

| |
|---|
| Completed |
| In Progress |

The Water Quality Initiative Team – by the numbers.
4/27/15 to Present – Funded by the MLRC

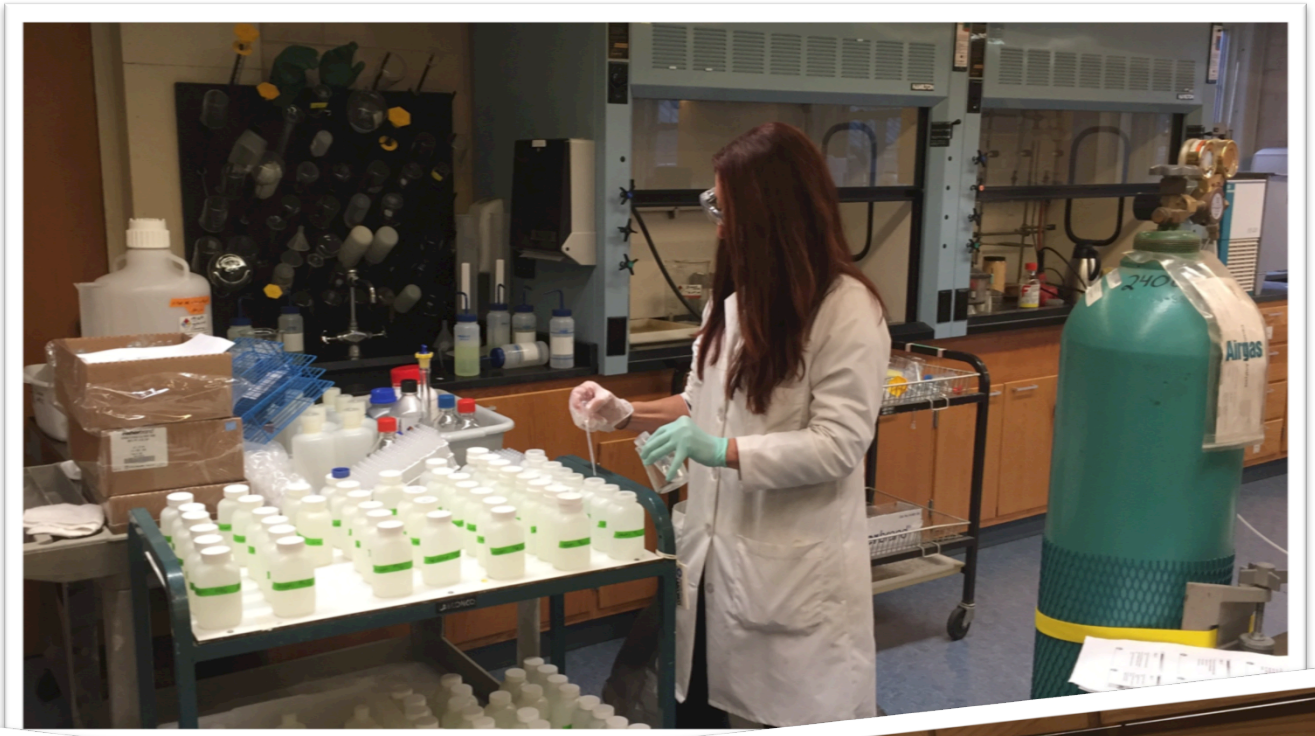
**MLRC** staff (Anne, Logan and Brenda): 1755 hours
**BRCA** staff (Nathan): 45 hours
**Colby** students (Sergio, Francis, Kara, Ellie, and Danqing ): 2100 hours
**Volunteers**: 14 wonderful volunteers (2 on LP, 3 on Mess., 4 on NP and 5 on EP) contributing over 250 hours of boat support

**Sampling Summary**: (Temp, DO, nutrients, Secchi, sediments, plankton)
East Pond: 21 sampling visits
Great Pond I: 22, Great Pond II: 24
Long Pond (north): 33, LP (south): 34
Messalonskee I: 18, Mess, II: 17
McGrath Pond: 18
North Pond: 17
Salmon Pond: 18

The Water Quality Initiative Team – by the numbers.
4/27/15 to Present

**Public Relations**:
High school and junior high school students
Included community in sample collection
Resource to residents with lake WQ questions
Lake association meetings
Real time data on the MLRC website
Seasonal updates on the MLRC website
Interactive map with instructional brochures
WQ updates at MLRC Farmers' Market
Collaboration with Linda Bacon at the ME-DEP
QC with Pete Kallin for Long Pond data

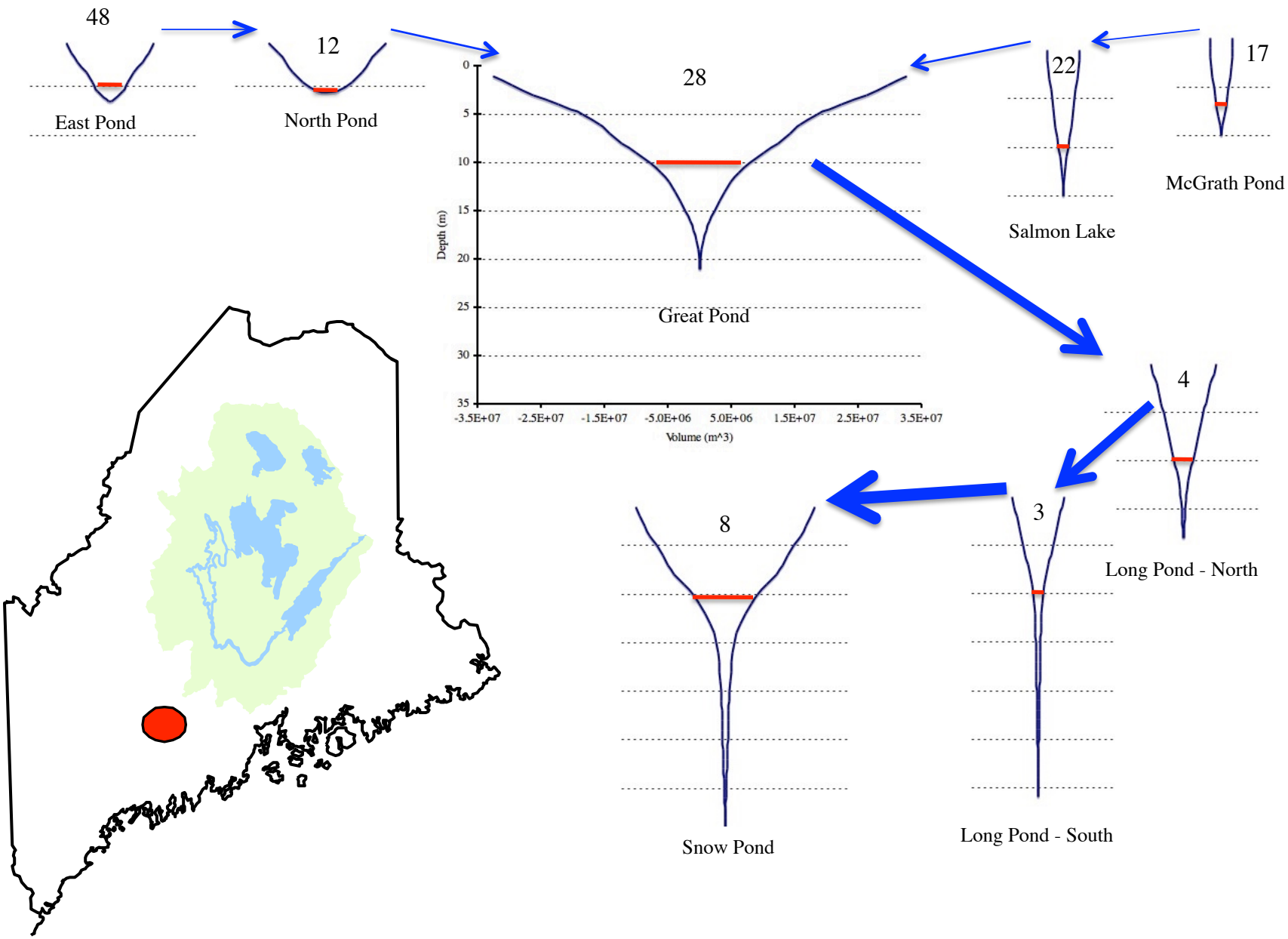
**Colby:**
Trucks – 1
Boats – 3
Instrumentation - ICP-ES, LC-MS, FlowCam
    Lachat, ovens, freezers, reagents ….
Buoy
Whitney King and Denise Bruesewitz


Airgas

So let’s look at some data!!!

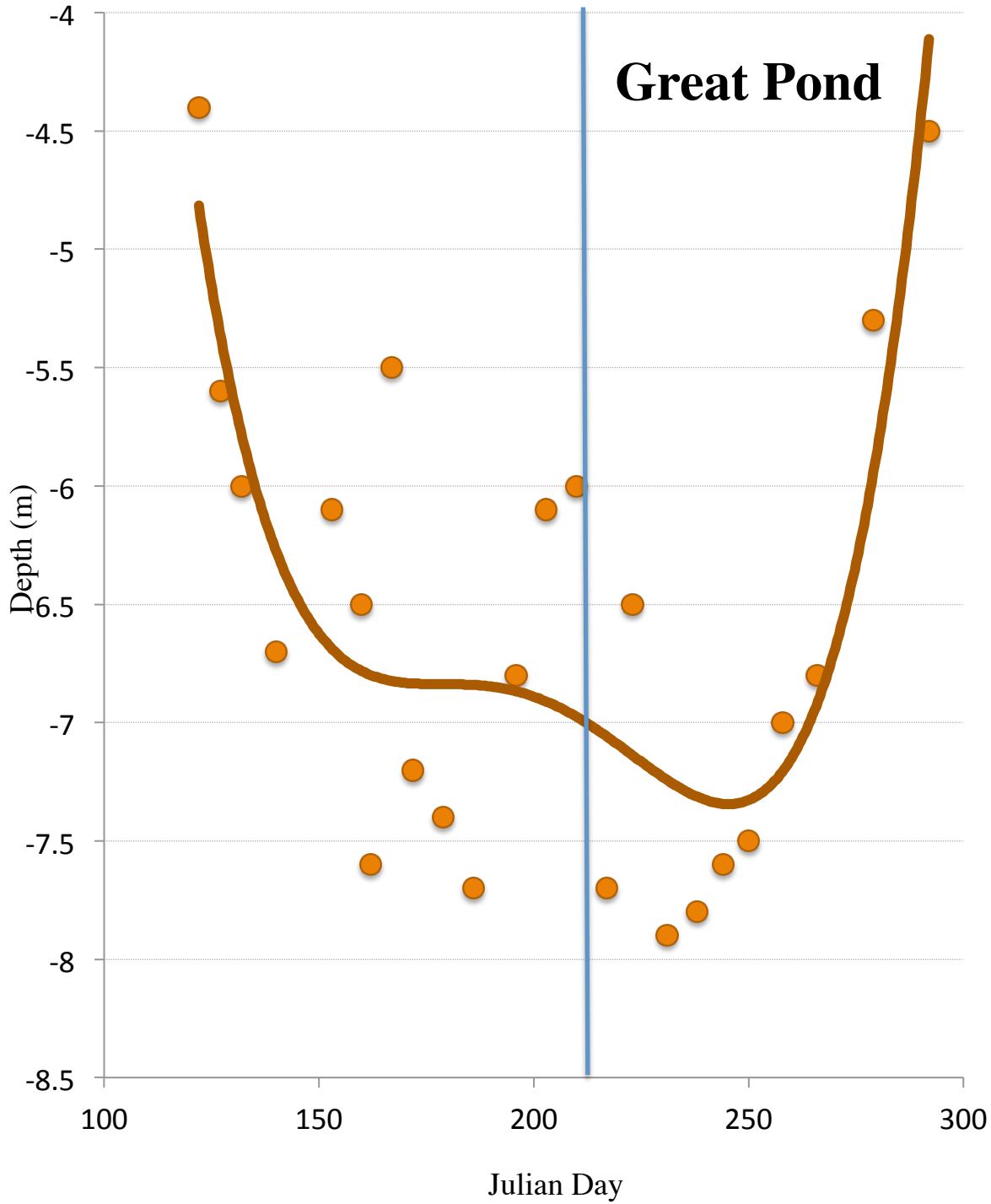
We will use Great Pond as an example followed by data from each lake.

# Hydrology of the Belgrade Lake Chain

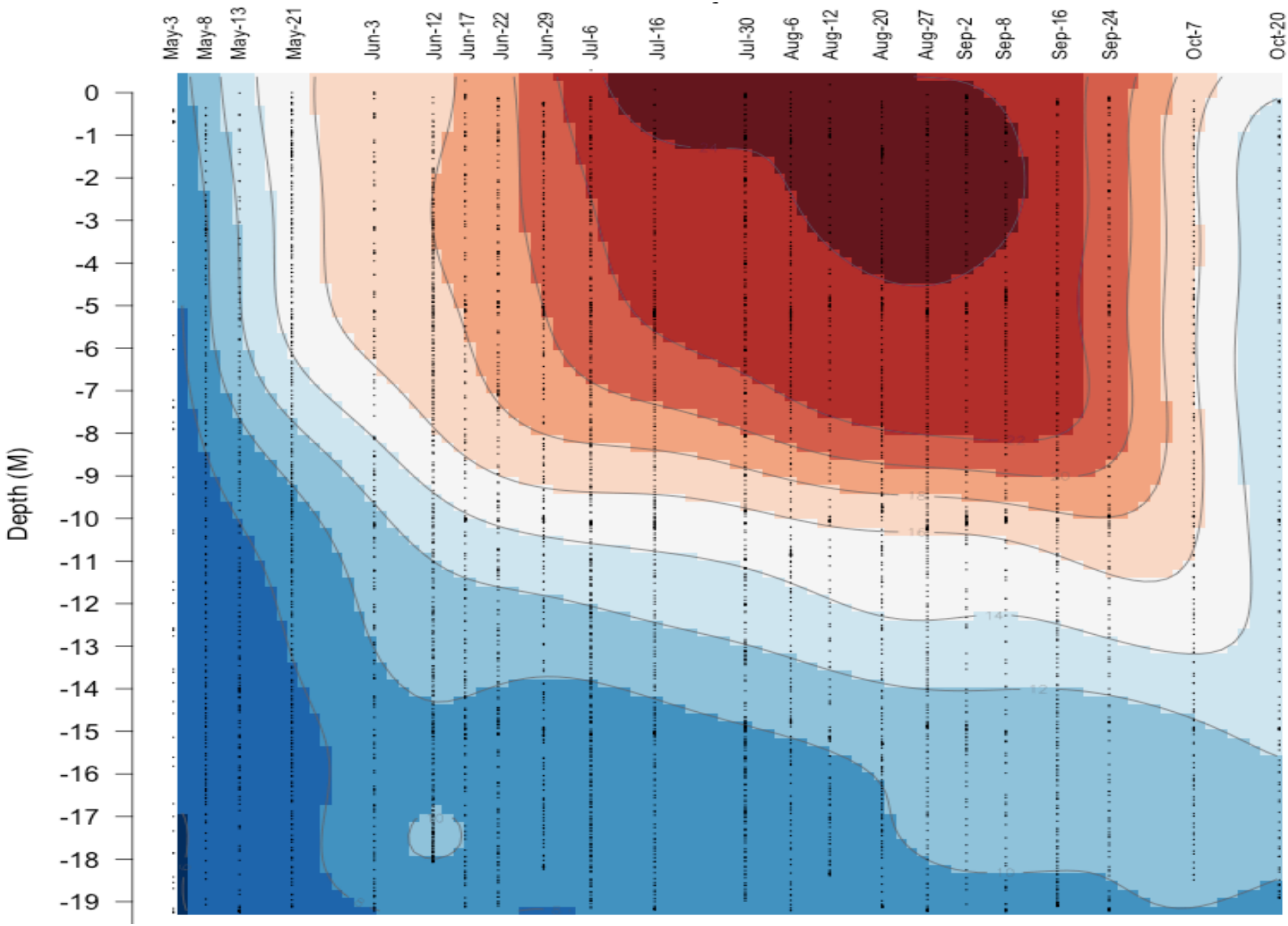


| | |
|---|---|
| Area ($km^2$) | 35 |
| Volume (millions $m^3$) | 24 |
| Mean Depth (m) | 6.4 |
| Morphometric Ratio | 1.09 |
| Thermocline Depth (m) | 8 |
| Anoxic Factor (lake area * days) | 6.80 |
| $O_2$ Loss Rate (metric tons/day) | 2.08 |
| Flushing Rate (#/year) | 0.43 |
| Secchi Mean (M) | 6.8 |
| | |
| Days Sampled | 22 |
| Number of Samples | 5,982 |

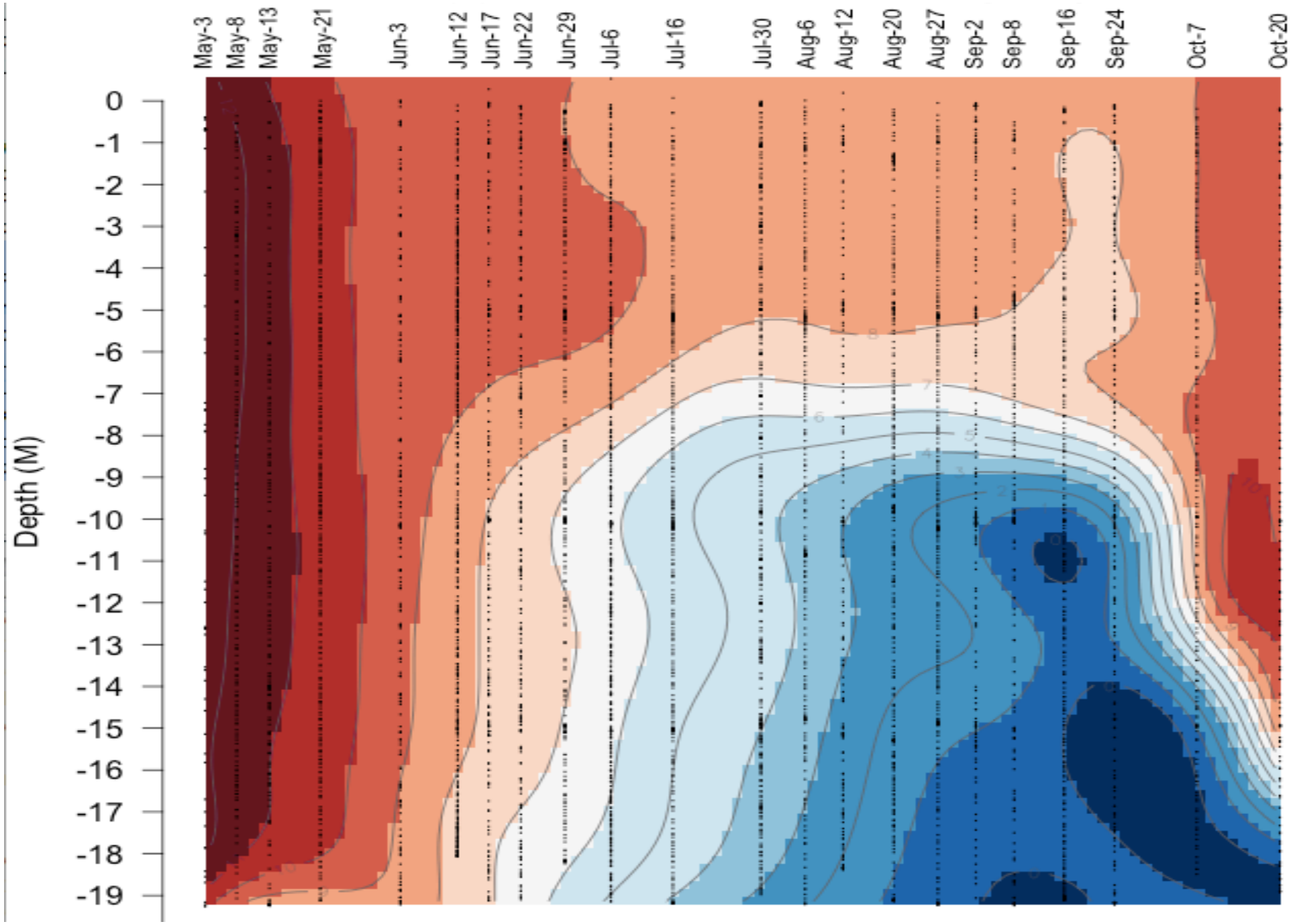
| Depth (M) | % Volume | % Surface Area |
|---|---|---|
| 1 | 15.28 | 7.31 |
| 2 | 13.92 | 9.80 |
| 3 | 12.35 | 9.91 |
| 4 | 10.49 | 13.43 |
| 5 | 8.65 | 9.90 |
| 6 | 7.43 | 5.61 |
| 7 | 6.63 | 4.42 |
| 8 | 5.76 | 6.53 |
| 9 | 4.74 | 6.29 |
| 10 | 3.71 | 6.68 |
| 11 | 2.85 | 4.26 |
| 12 | 2.26 | 3.14 |
| 13 | 1.81 | 2.56 |
| 14 | 1.43 | 2.23 |
| 15 | 1.07 | 2.33 |
| 16 | 0.73 | 1.96 |
| 17 | 0.45 | 1.51 |
| 18 | 0.26 | 0.89 |
| 19 | 0.13 | 0.76 |
| 20 | 0.04 | 0.42 |
| 21 | 0.00 | 0.06 |



# Great Pond Temperature (ºC)

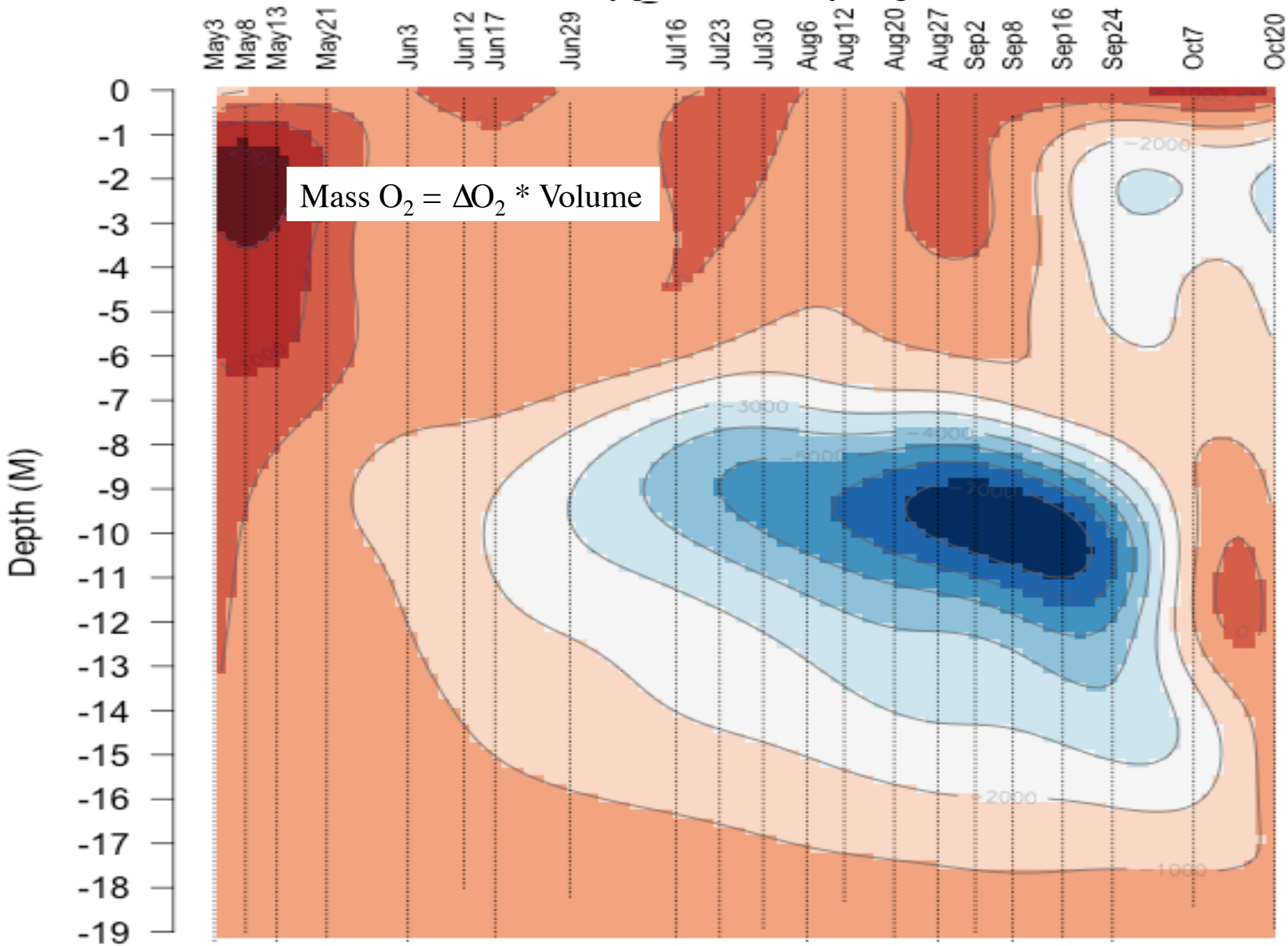


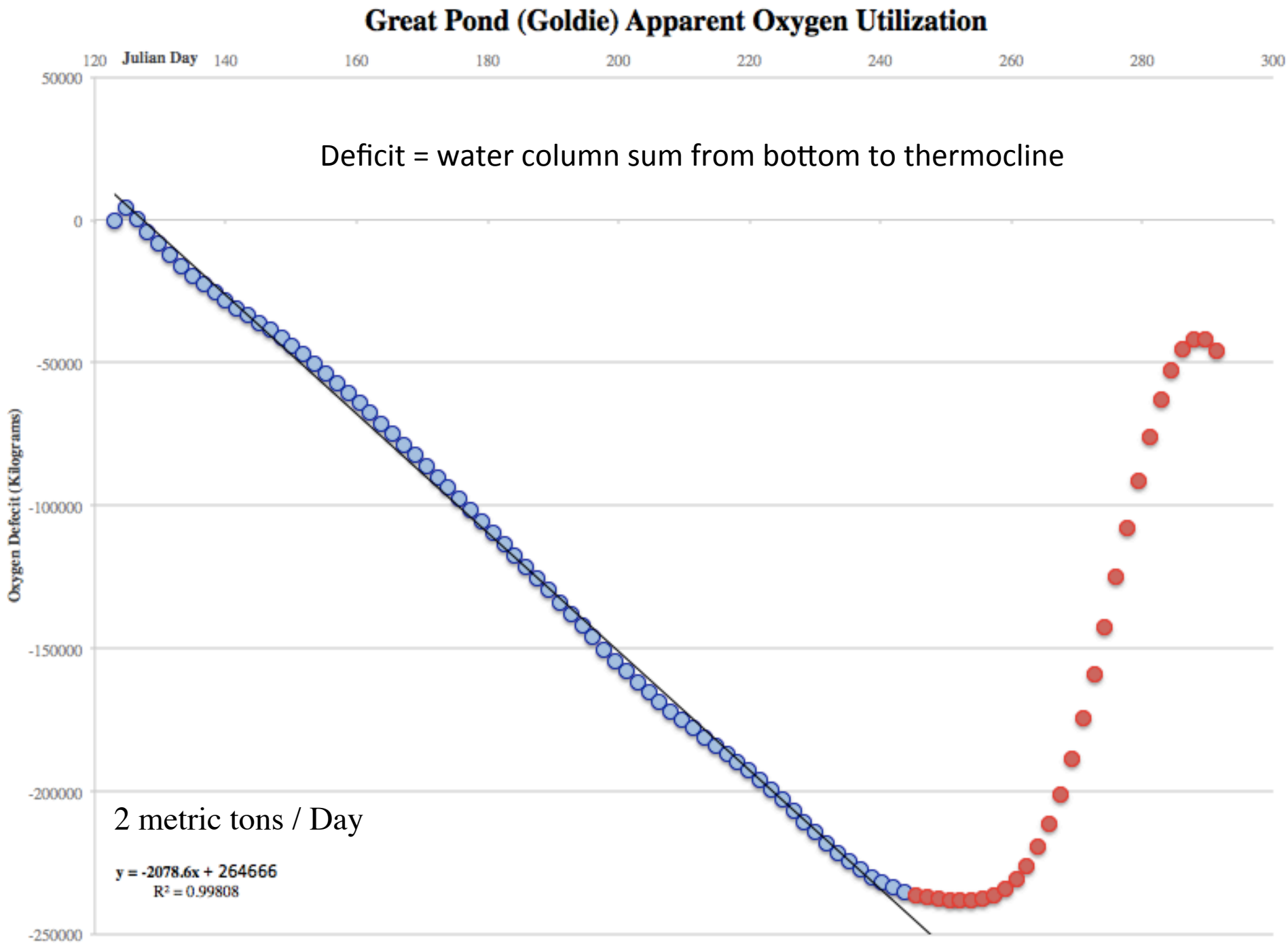
# Great Pond Oxygen Concentration (ppm)



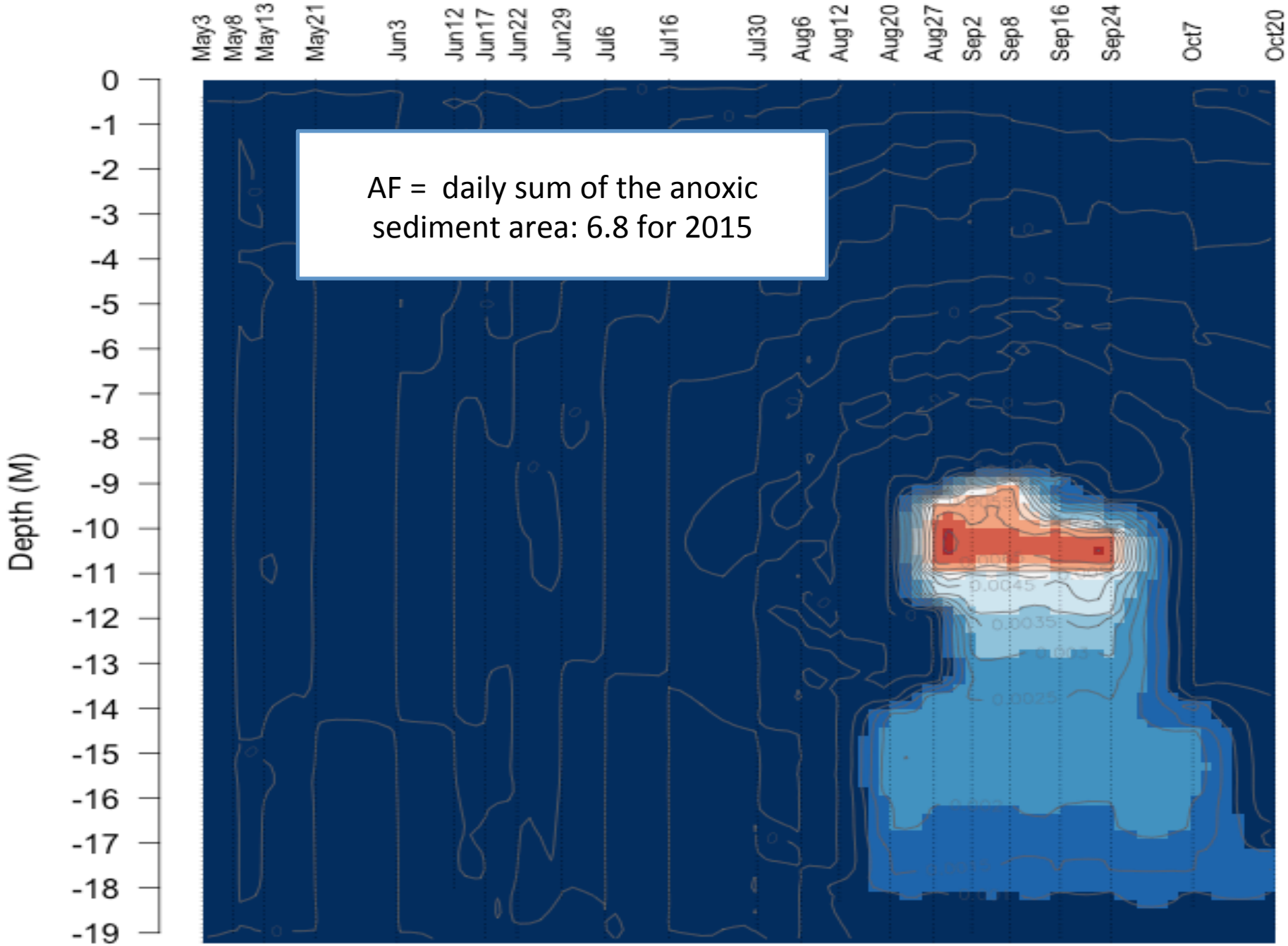
VS.

# Great Pond Oxygen Anomaly (kg)



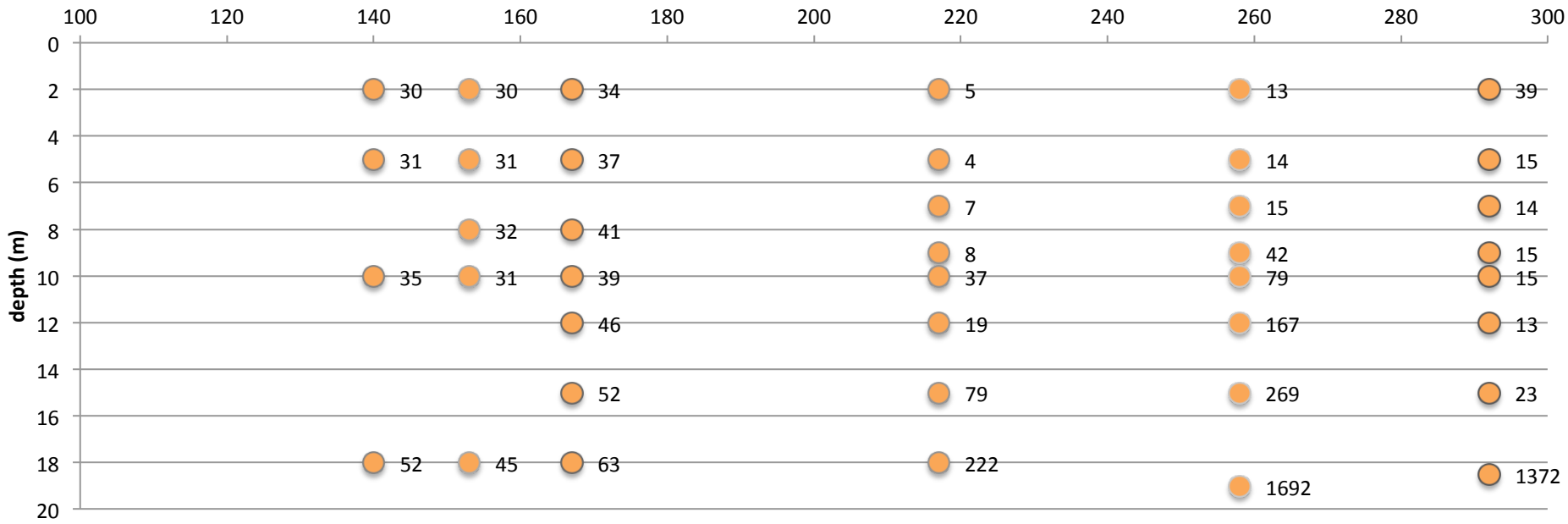

Great Pond (Goldie) Apparent Oxygen Utilization
Julian Day
120
140
160
180
200
220
240
260
280
300
50000
0
-50000
-100000
-150000
-200000
-250000
Oxygen Defecit (Kilograms)
Deficit = water column sum from bottom to thermocline
2 metric tons / Day
y = -2078.6x + 264666
R² = 0.99808

# Great Pond Anoxic Sediment (Fraction of Lake Area)

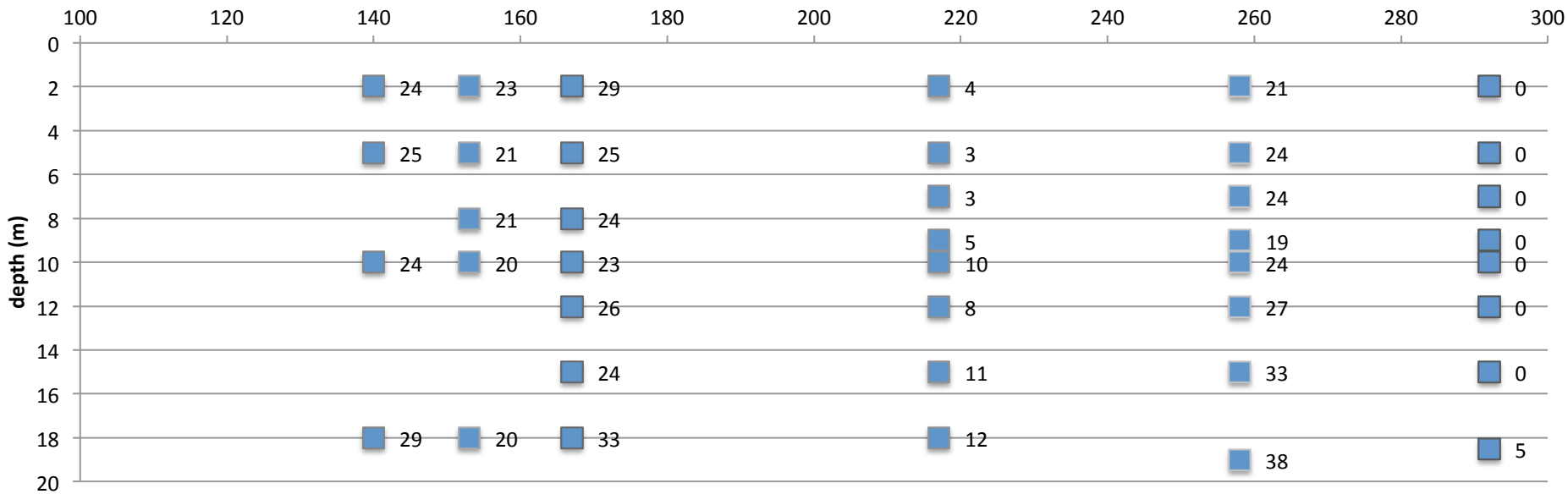



AF = daily sum of the anoxic sediment area: 6.8 for 2015

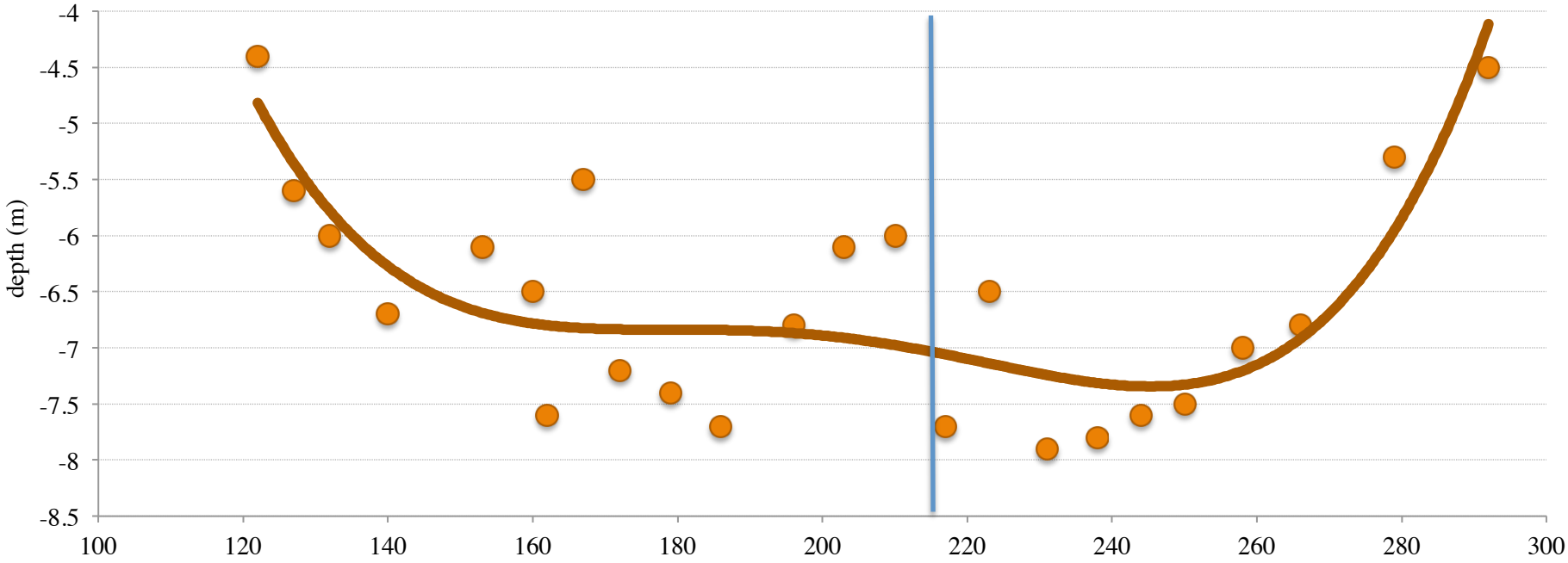
# Great Pond Iron Concentration (ppb)



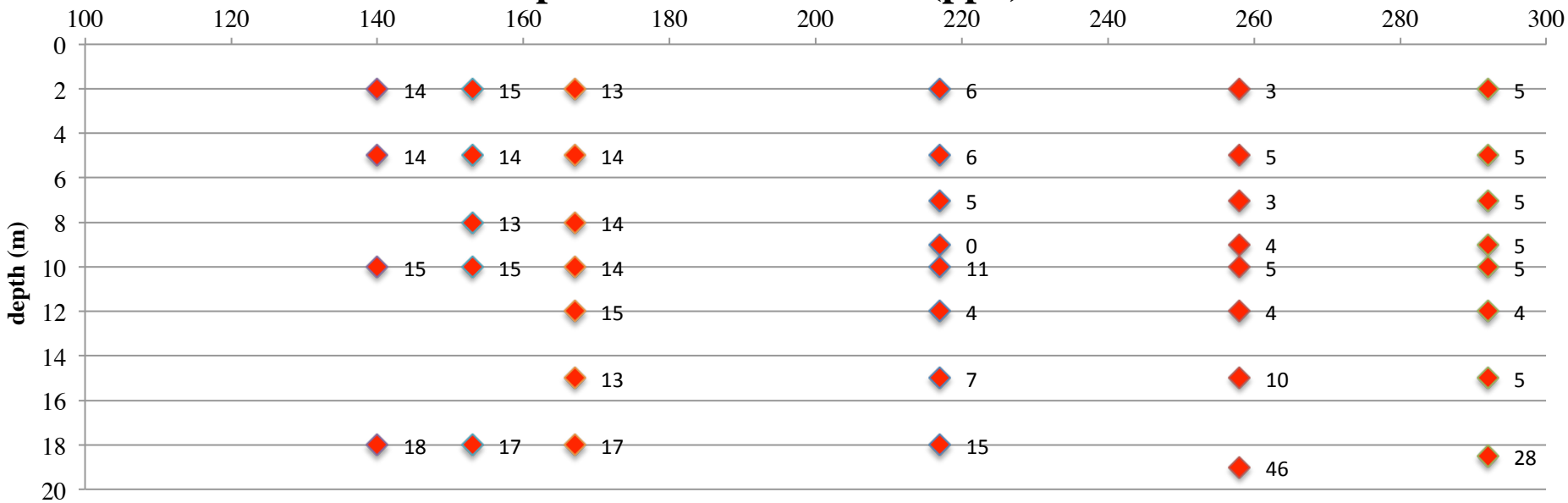

# Aluminum Concentration (ppb)



# Great Pond Secchi Depth



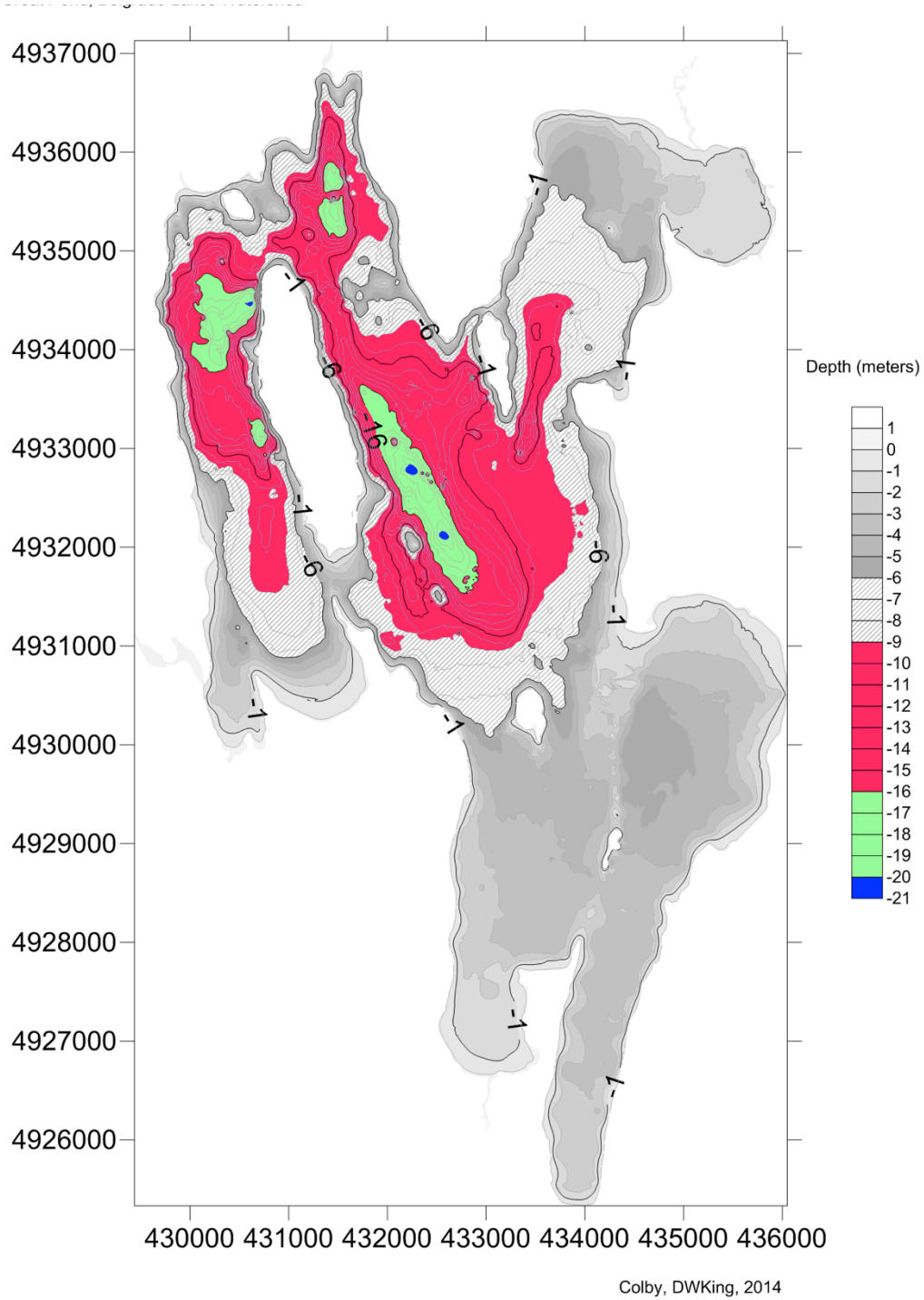

# Phosphorus Concentration (ppb)

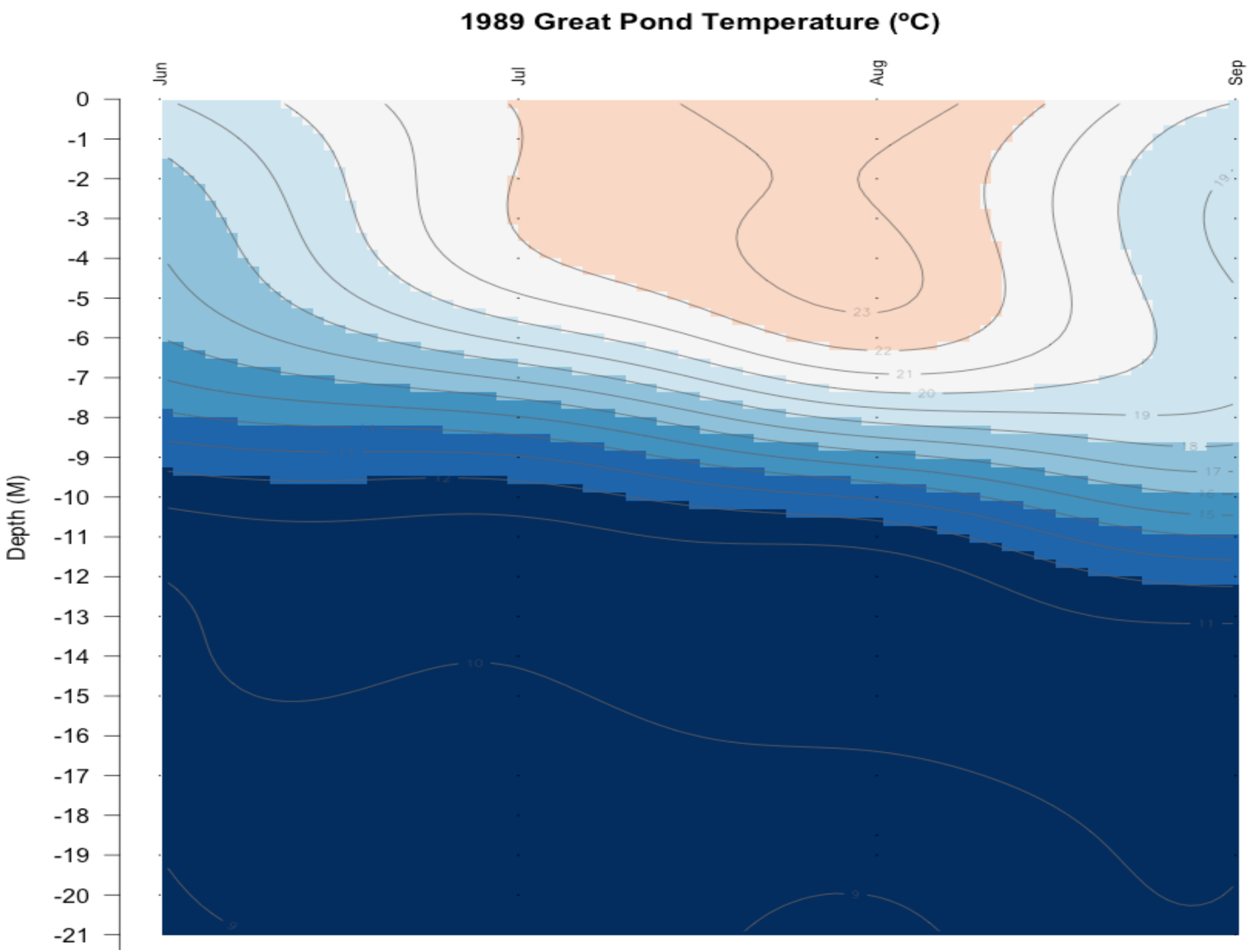


Trends are defined by the historical data.

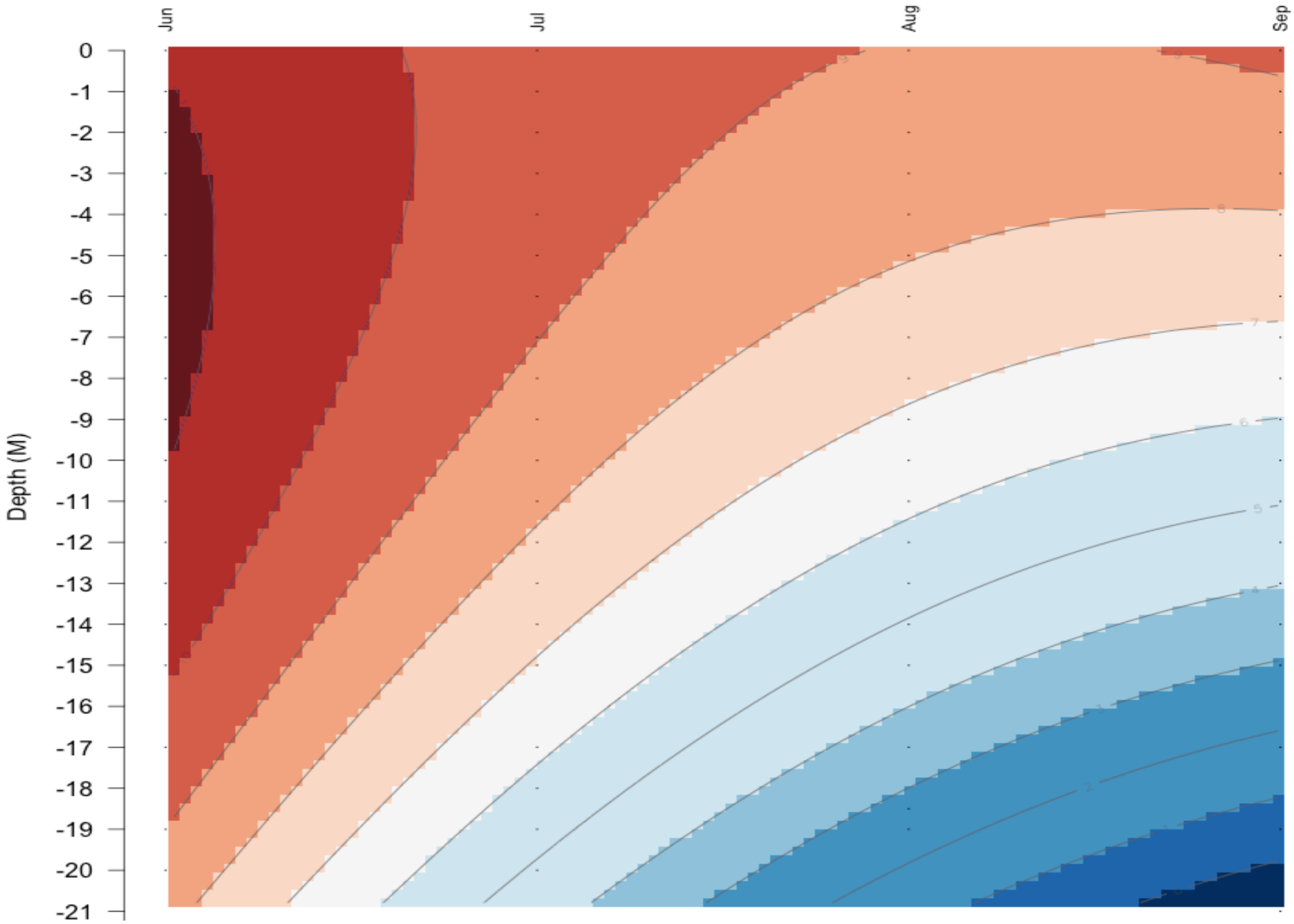
We have 40 years of lake data of variable quality.

We will use 1989 as an example.

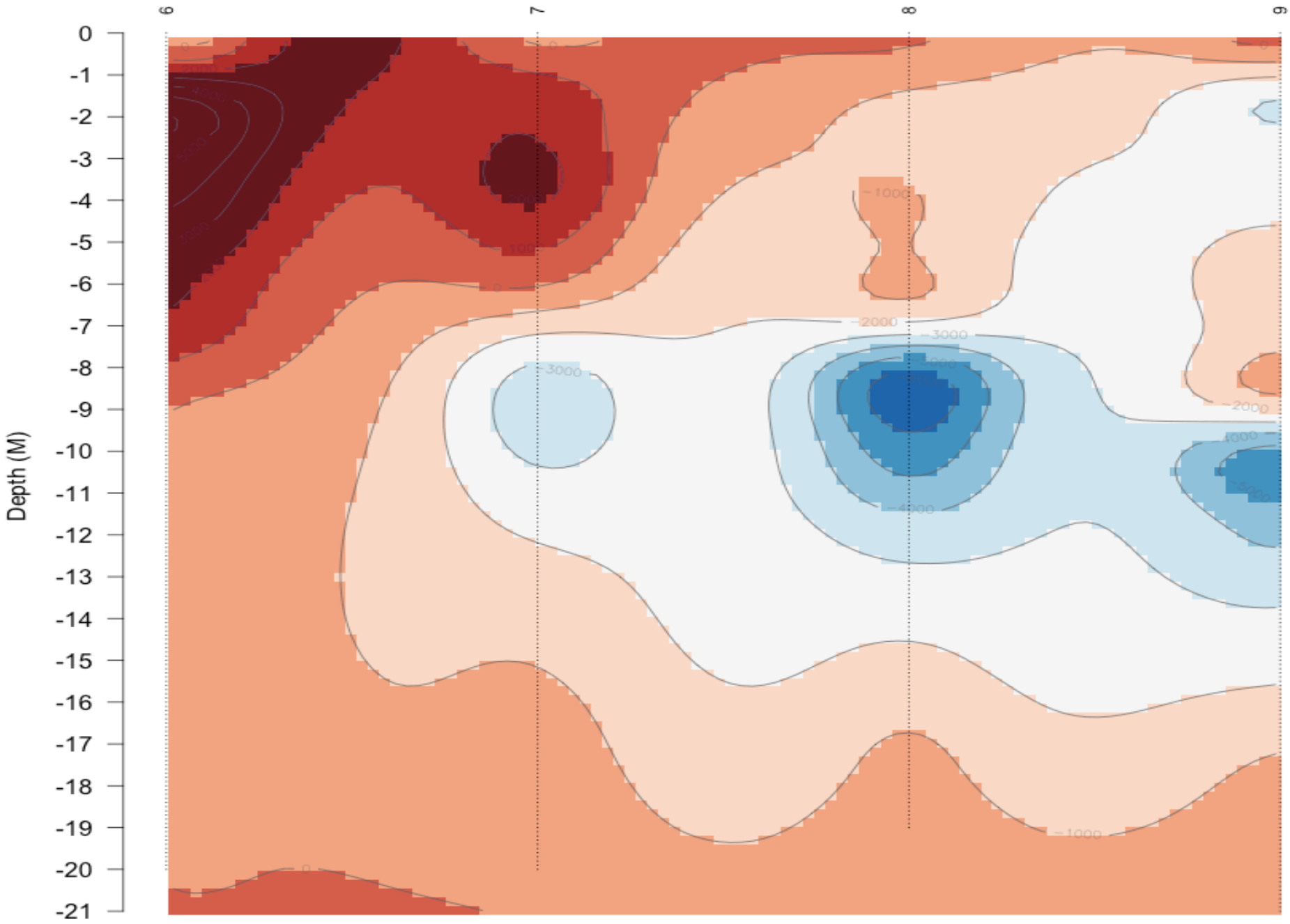


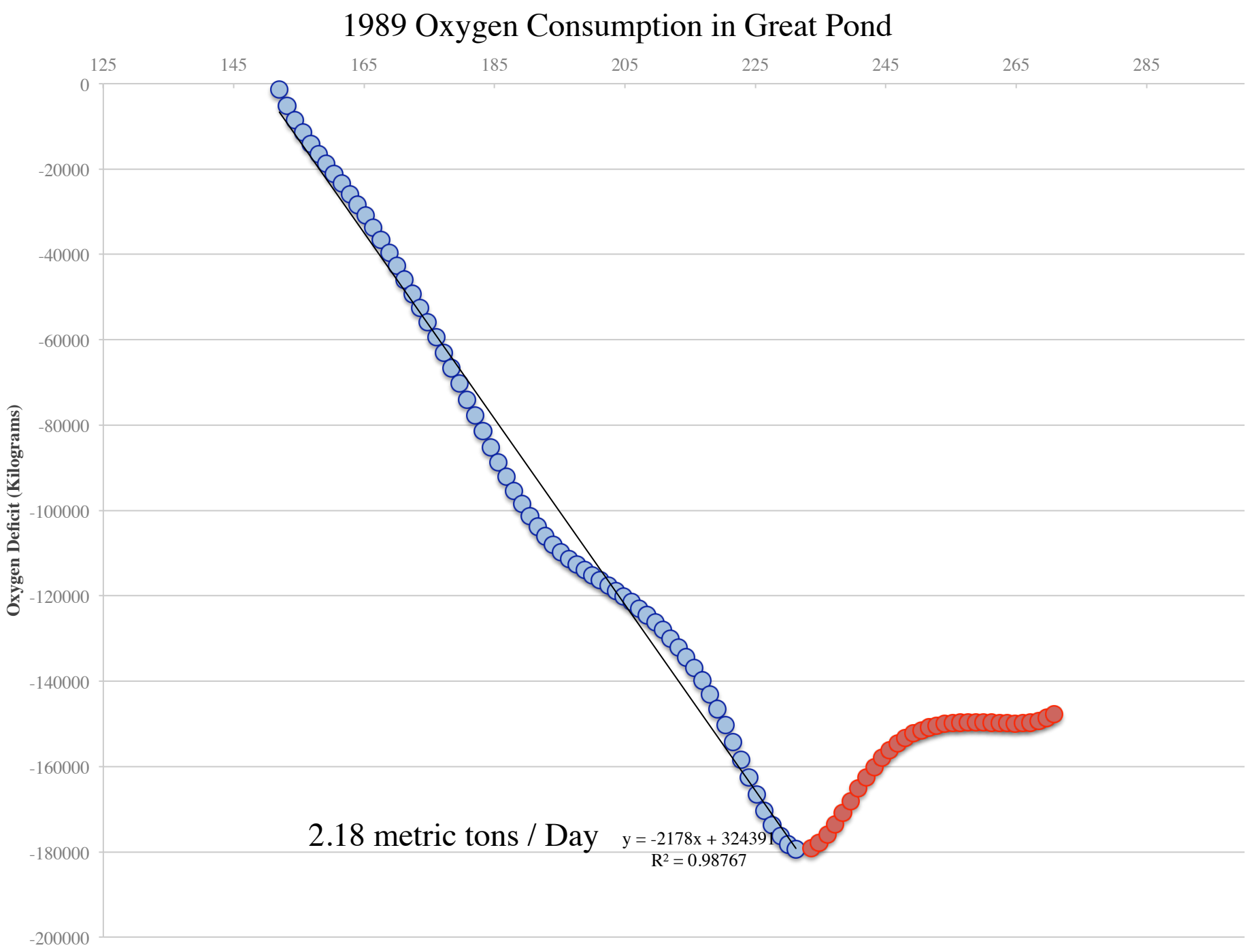

1989 Great Pond Temperature (ºC)
Jun
Jul
Aug
Sep
Depth (M)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9

# 1989 Great Pond Oxygen Concentration (ppm)

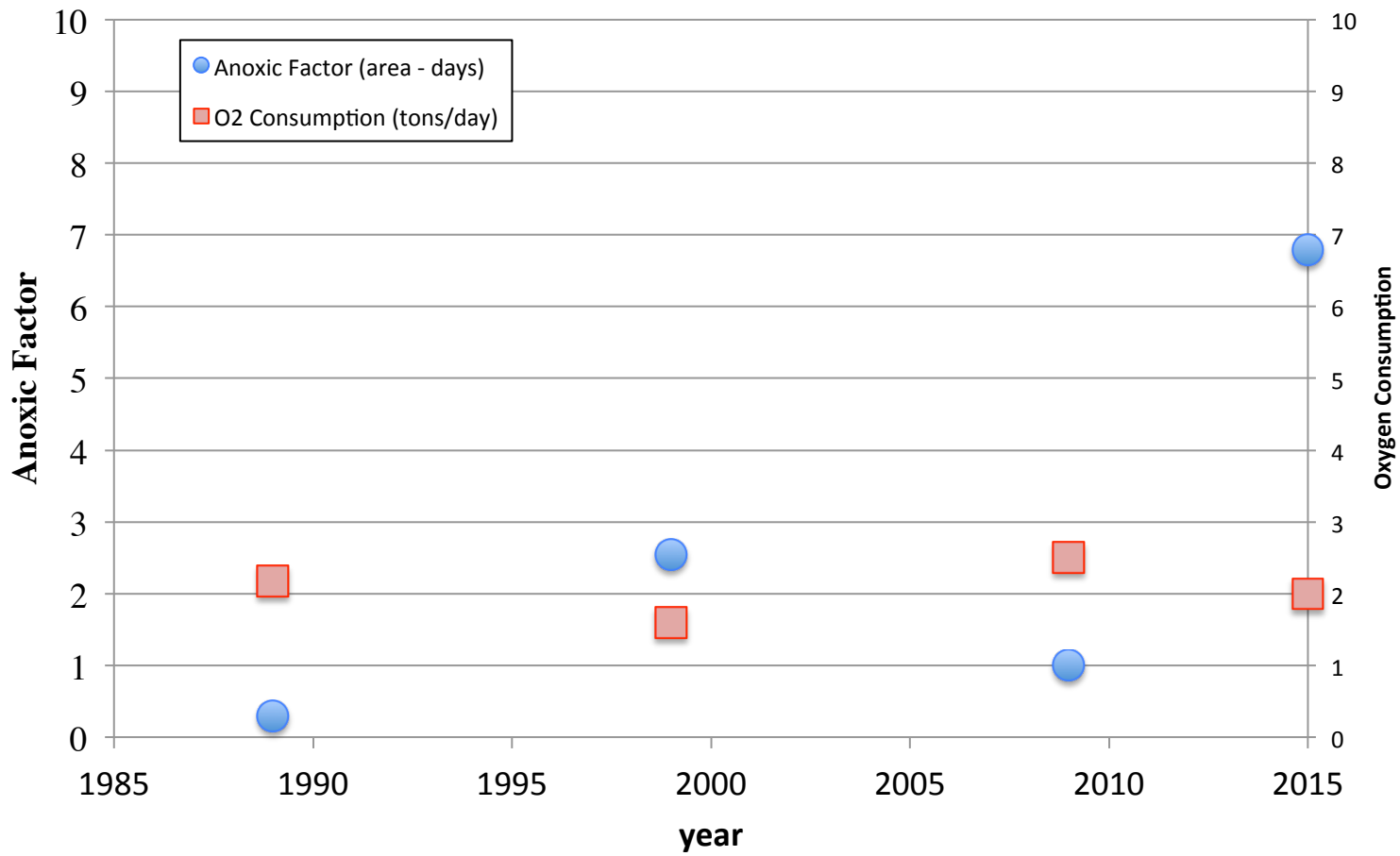


# 1989 Great Pond Oxygen Anomaly (kg)




1989 Oxygen Consumption in Great Pond
125
145
165
185
205
225
245
265
285
0
-20000
-40000
-60000
-80000
-100000
-120000
-140000
-160000
-180000
-200000
Oxygen Deficit (Kilograms)
2.18 metric tons / Day
y = -2178x + 324391
R² = 0.98767

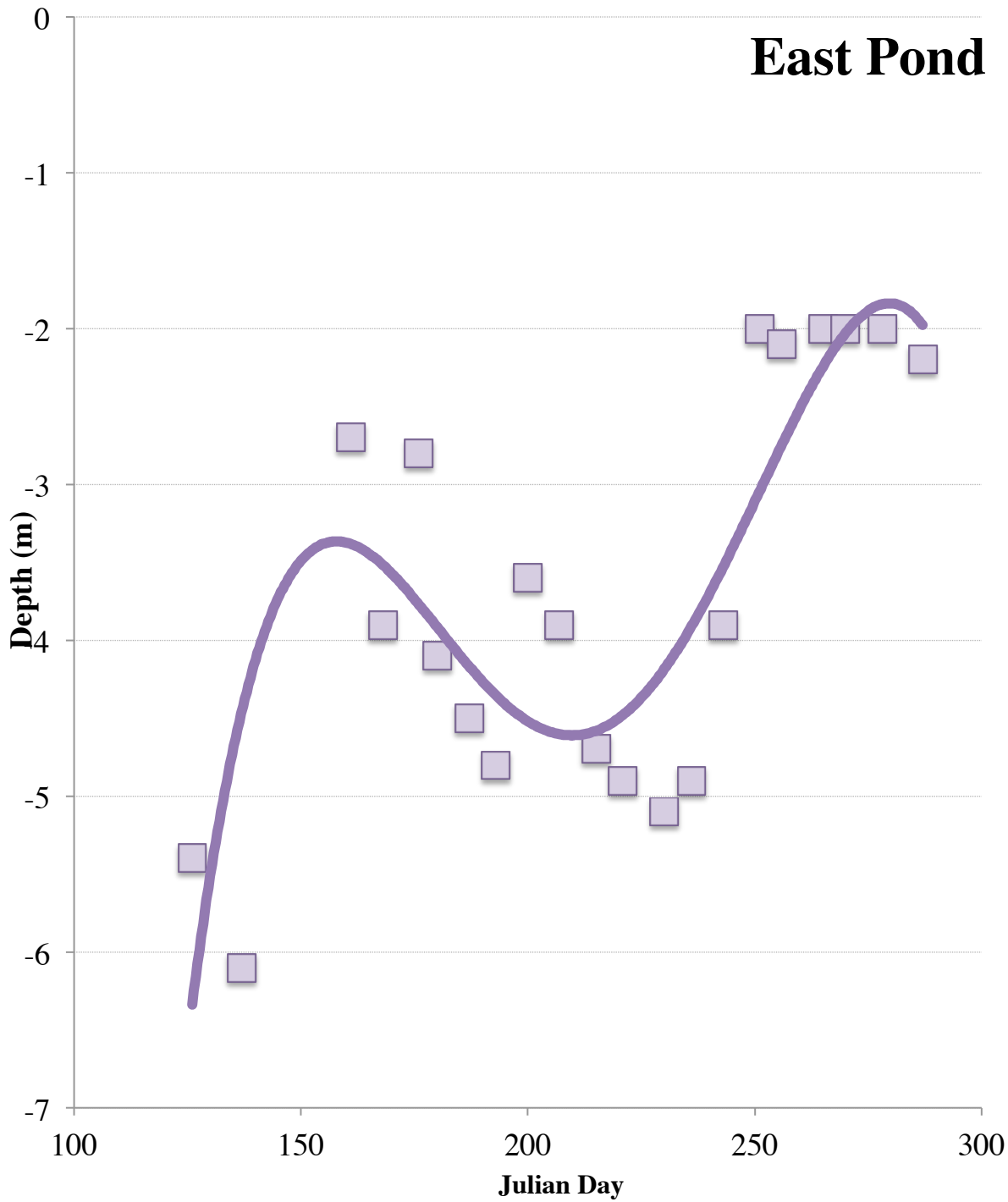
Great Pond – Historic Oxygen Metrics - DRAFT



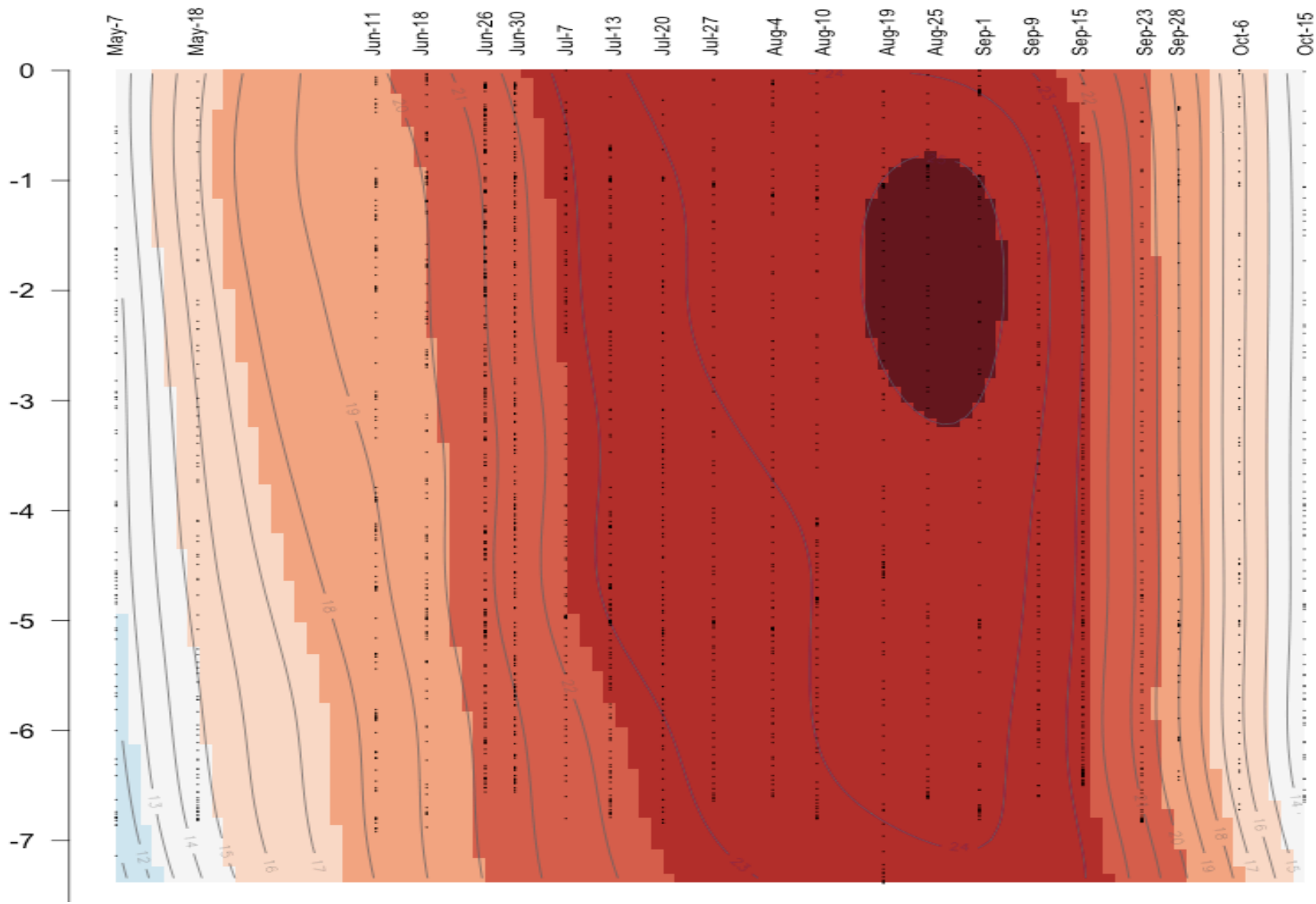

Great Pond seems to be consuming oxygen at a fairly constant rate, but in recent years the lake has been consuming oxygen for a longer period of time resulting in expanded anoxia. This trend is not sustainable.

| | |
|---|---|
| Area ($km^2$) | 6.95 |
| Volume (millions $m^3$) | 3.37 |
| Mean Depth (m) | 5.49 |
| Morphometric Ratio | 2.08 |
| Thermocline Depth (m) | None |
| Anoxic Factor (lake area * days) | 2.88 |
| $O_2$ Loss Rate (metric tons/day) | 0.3 |
| Days Sampled | 19 |
| Flushing Rate (#/year) | 0.25 |
| | |
| Number of Samples | 2,328 |
| Secchi Mean (M) | 3.7 |

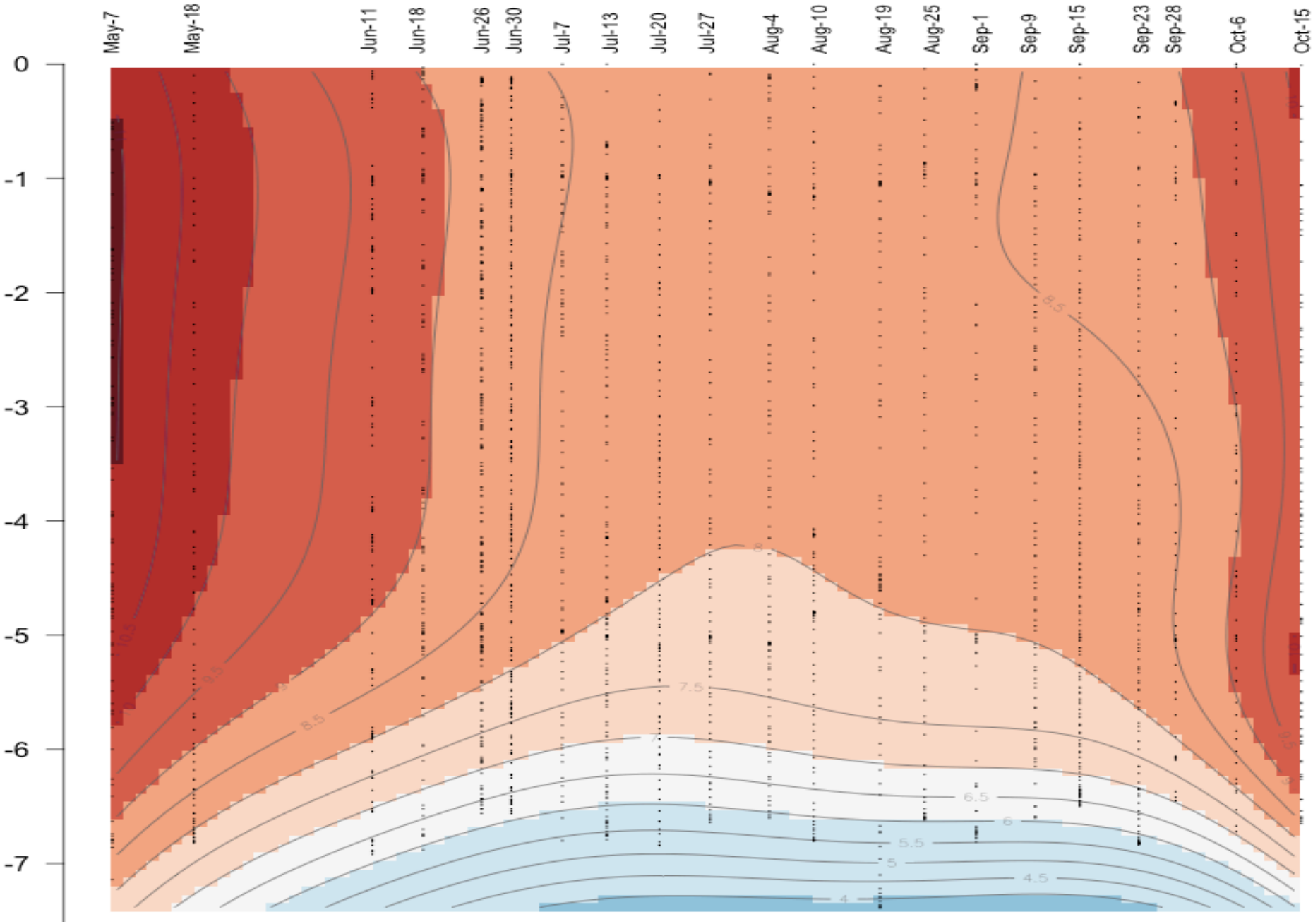
| Depth (M) | % Volume | % Surface Area |
|---|---|---|
| 0.5 | 13.1 | 25.0 |
| 1 | 12.4 | 24.1 |
| 1.5 | 11.7 | 22.2 |
| 2 | 11.1 | 21.4 |
| 2.5 | 10.1 | 20.0 |
| 3 | 9.0 | 17.9 |
| 3.5 | 7.7 | 15.7 |
| 4 | 6.4 | 13.1 |
| 4.5 | 5.5 | 10.9 |
| 5 | 4.8 | 9.6 |
| 5.5 | 4.2 | 8.4 |
| 6 | 3.1 | 7.2 |
| 6.5 | 1.0 | 4.4 |
| 7 | 0.1 | 0.3 |
| 7.5 | 0.0 | 0.0 |



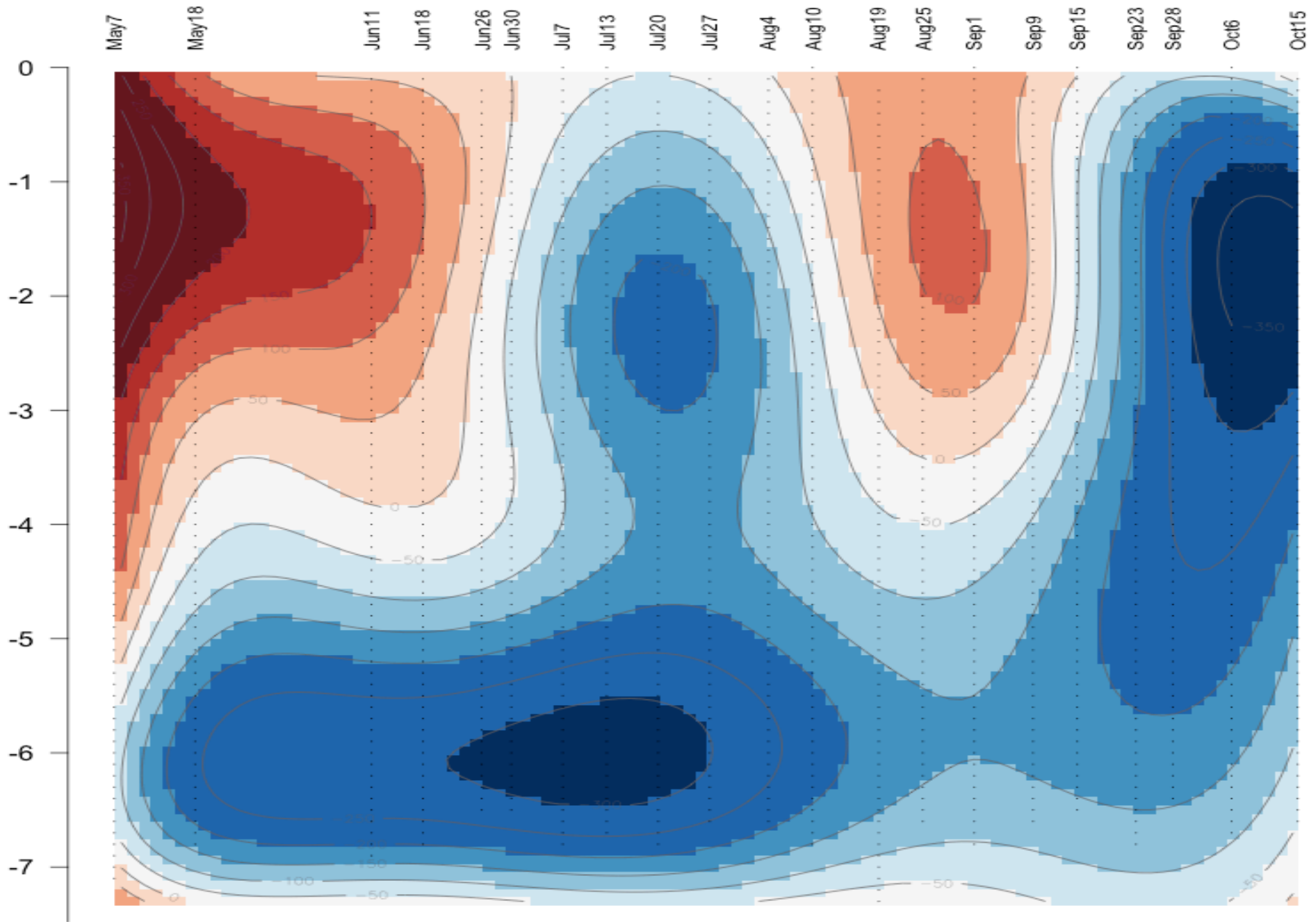
# East Pond Temperature (ºC)

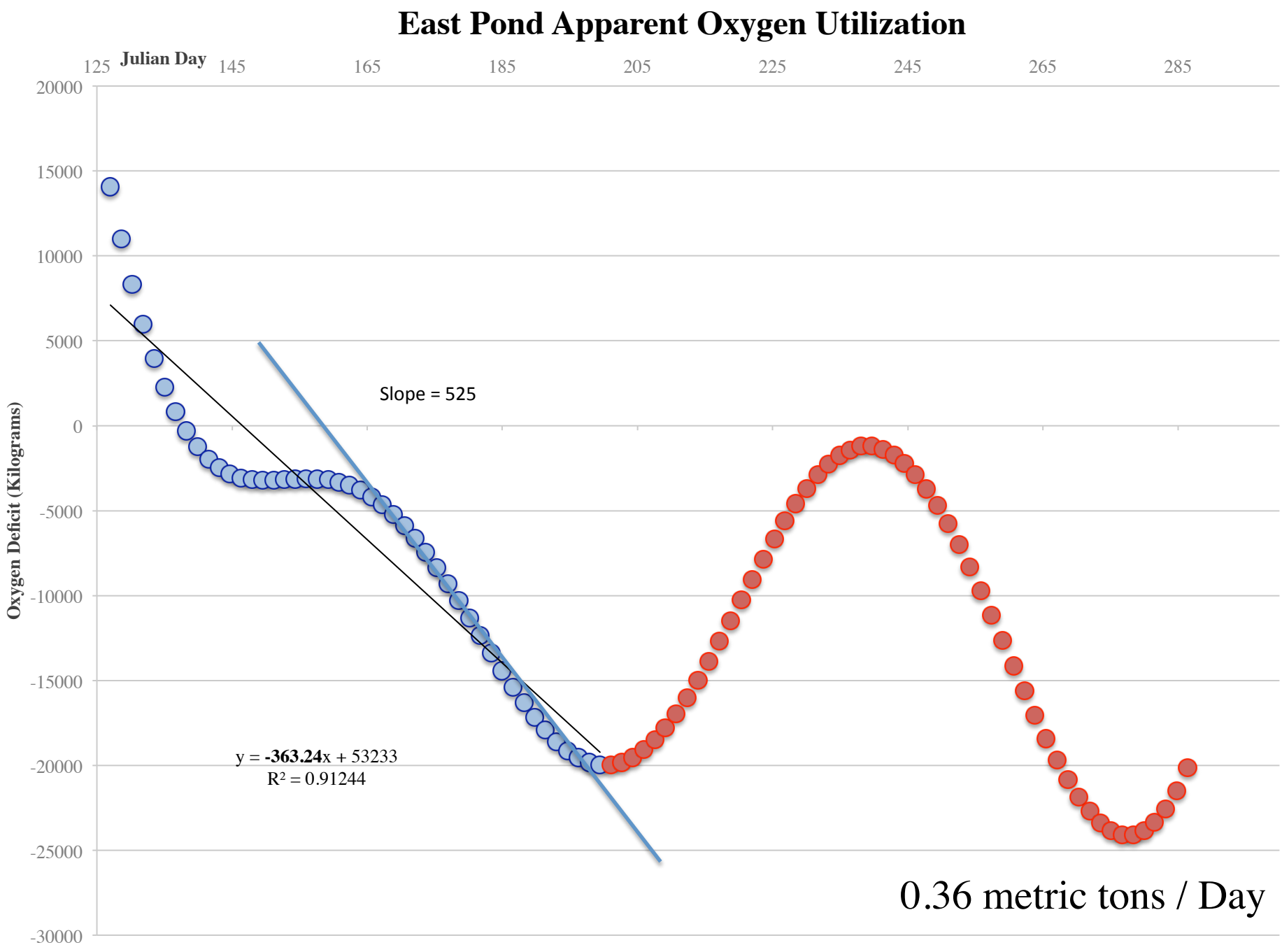


# East Pond Oxygen Concentration (ppm)

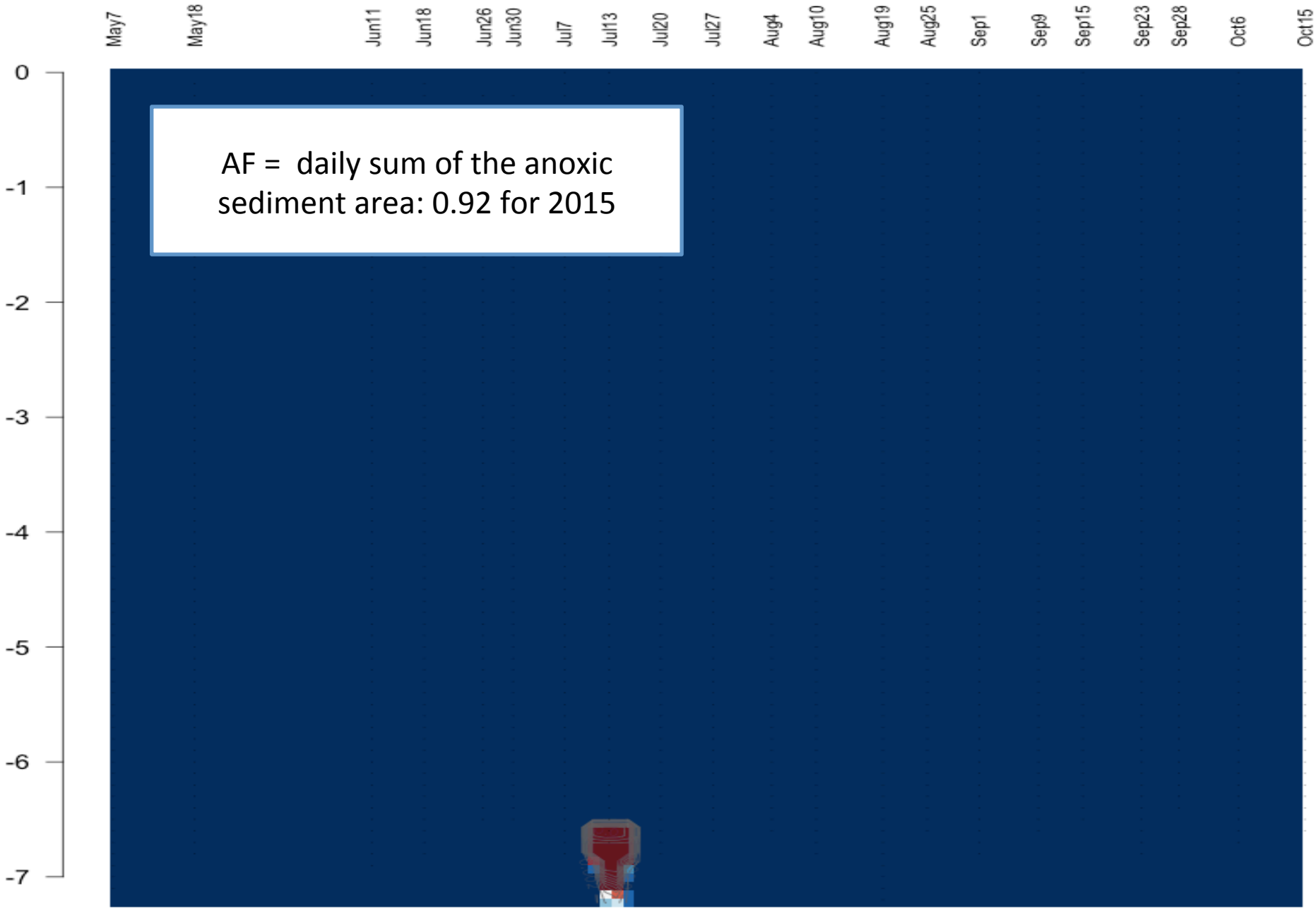


# East Pond Oxygen Deficit (kg)

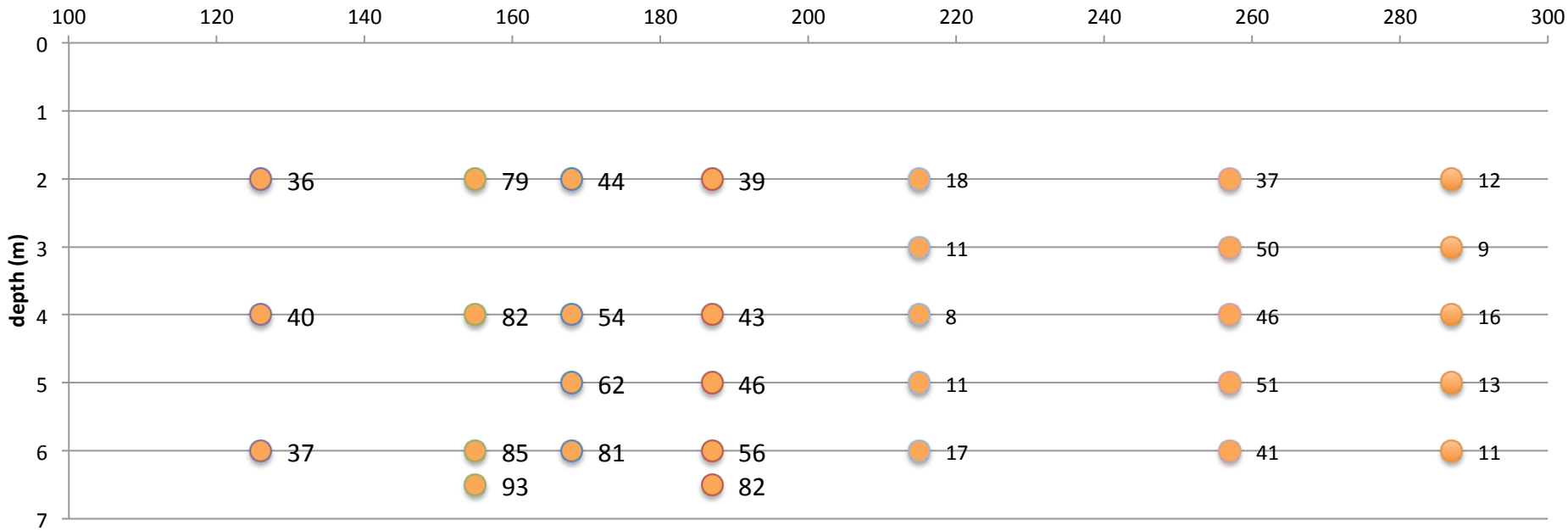



East Pond Apparent Oxygen Utilization
Julian Day
125
145
165
185
205
225
245
265
285
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
-25000
-30000
Oxygen Deficit (Kilograms)
Slope = 525
y = -363.24x + 53233
R² = 0.91244
0.36 metric tons / Day

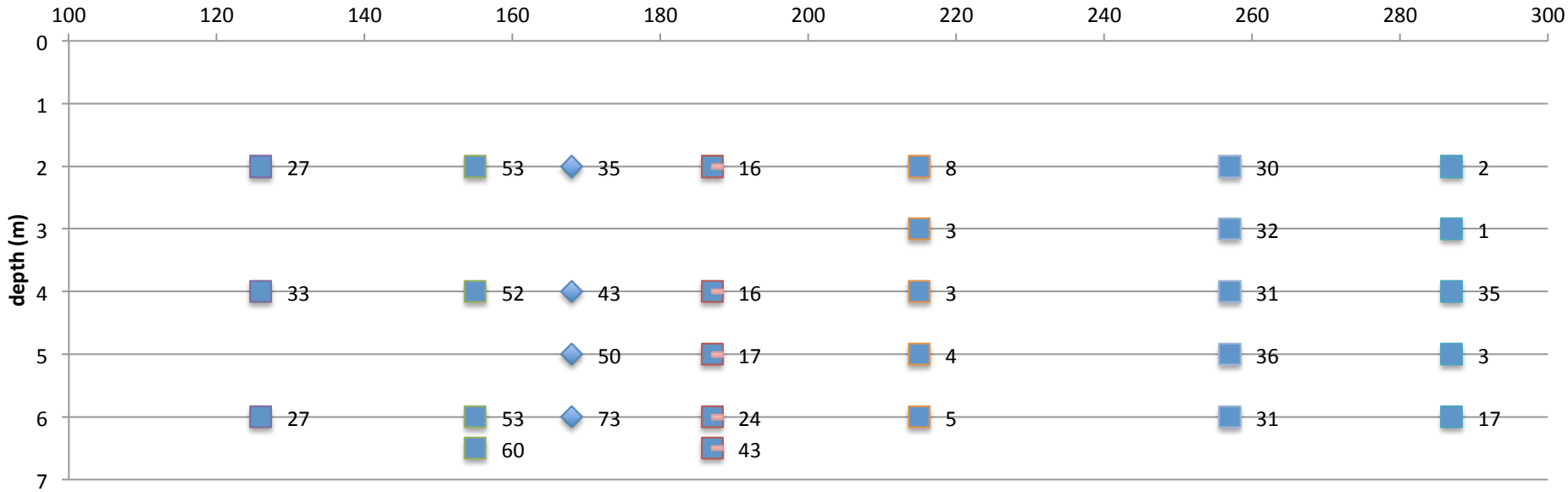
# East Pond Anoxic Sediment Area (Fraction of Lake Area)



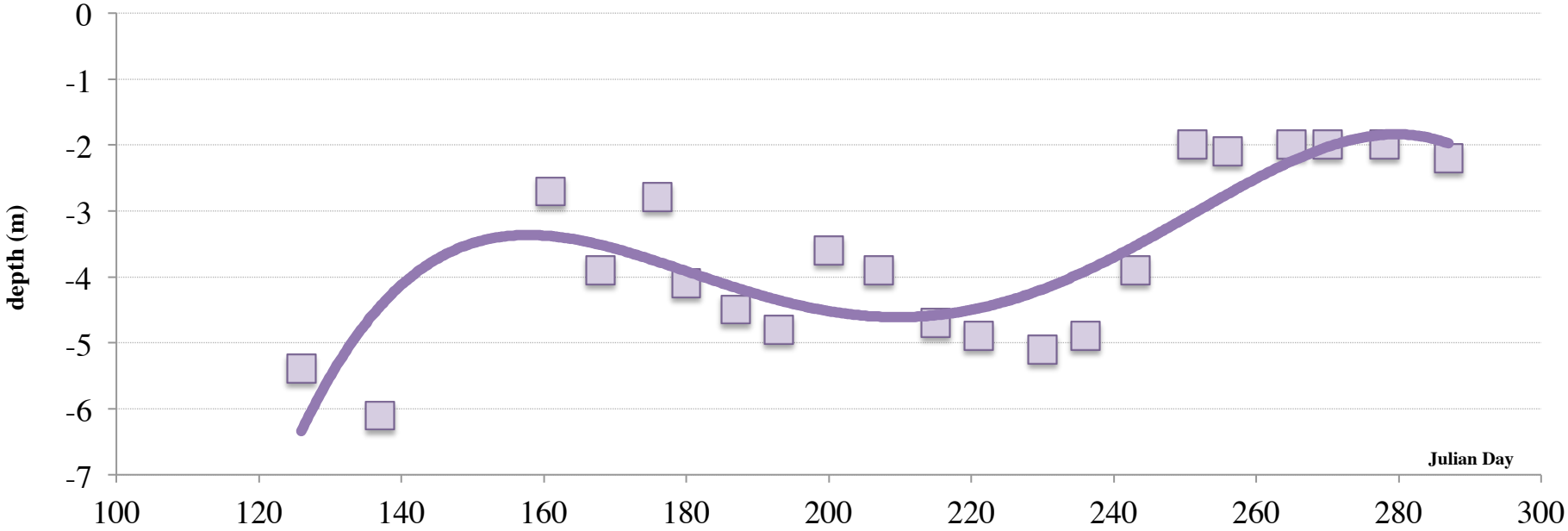
# East Pond Iron Concentration (ppb)



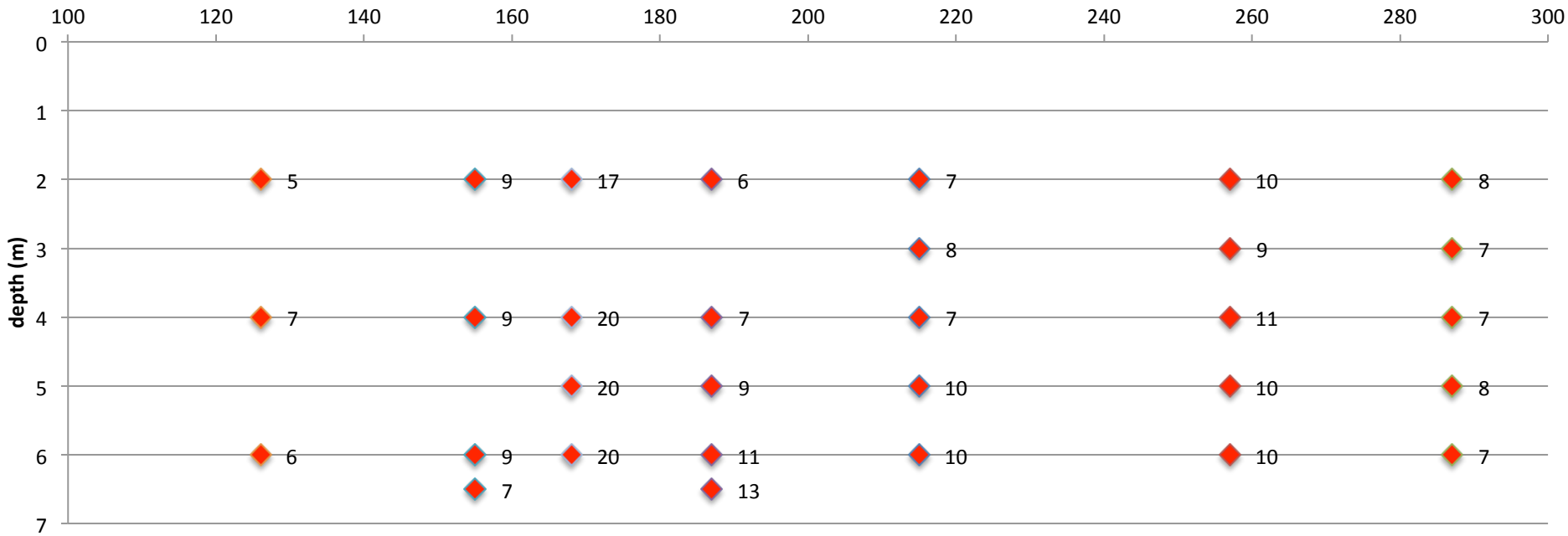

# Aluminum Concentration (ppb)



# East Pond Secchi Depth

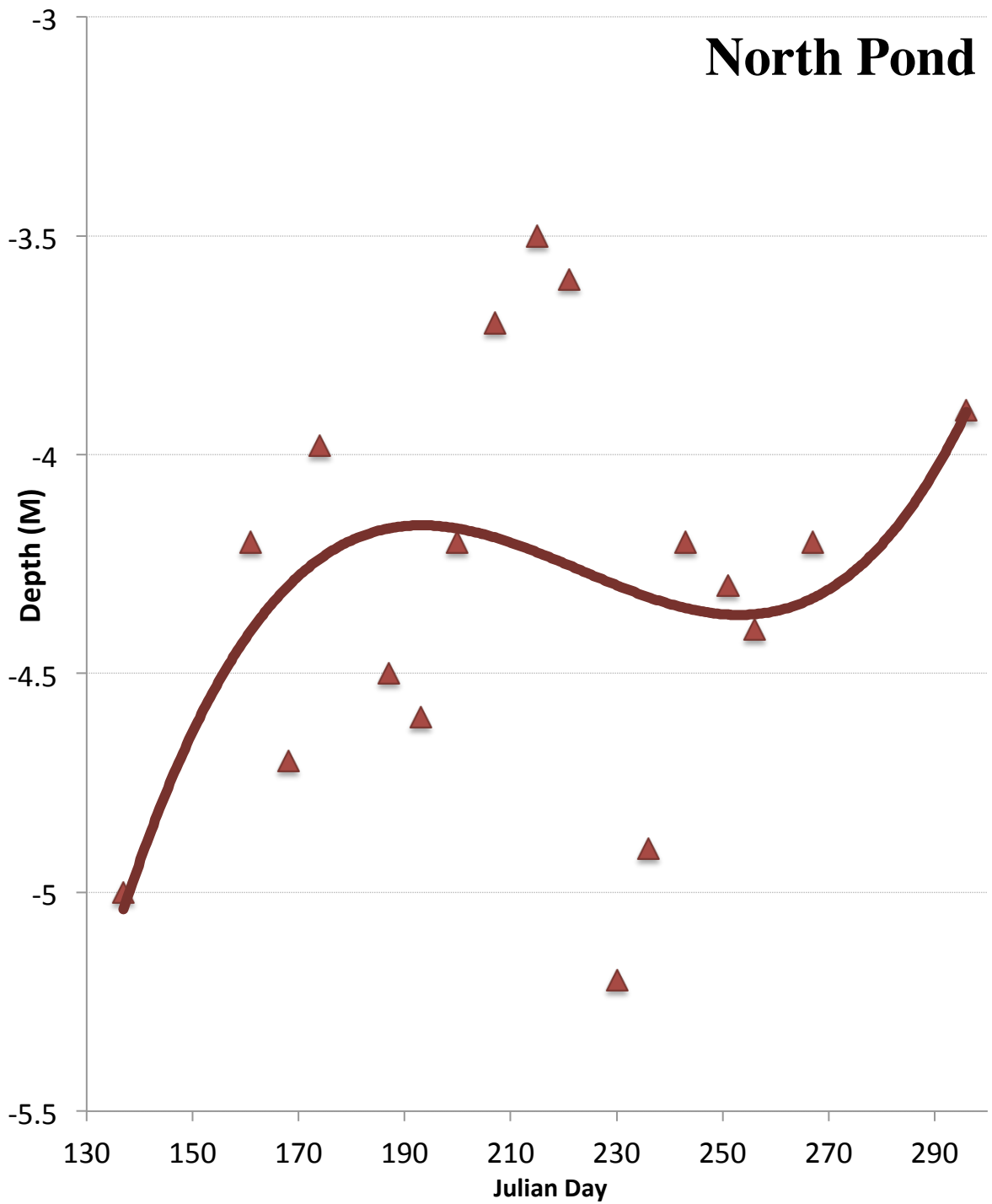



# Phosphorus Concentration (ppb)

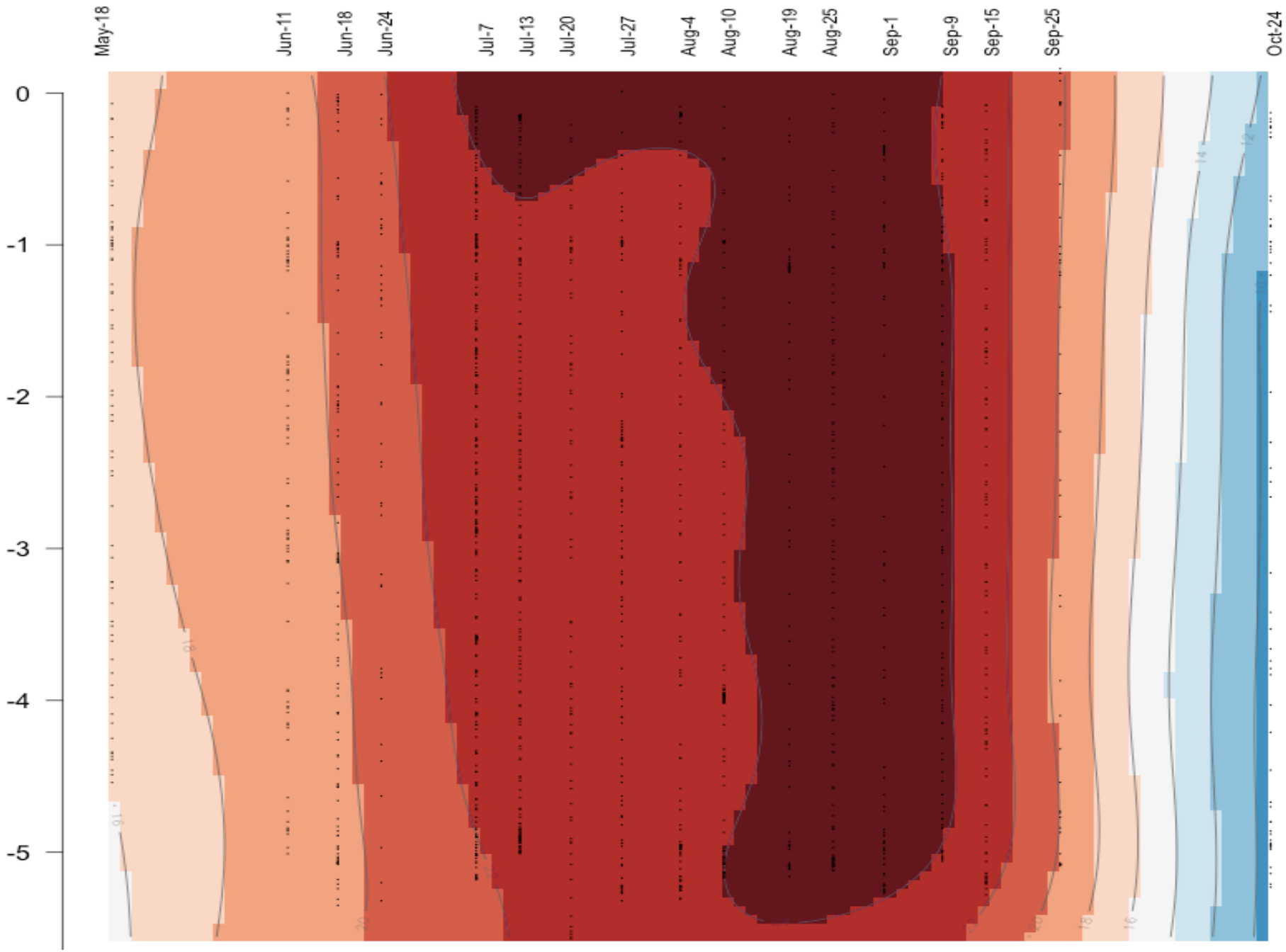


| | |
|---|---|
| Area ($km^2$) | 1.02 |
| Volume (millions $m^3$) | 2.05 |
| Mean Depth (m) | 3.96 |
| Morphometric Ratio | 1.24 |
| Thermocline Depth (m) | None |
| Anoxic Factor (lake area * days) | 0 |
| $O_2$ Loss Rate (metric tons/day) | 1 |
| Days Sampled | 16 |
| Flushing Rate (#/year) | 1 |
| | |
| Number of Samples | 1,652 |
| Secchi Mean (M) | 4.3 |

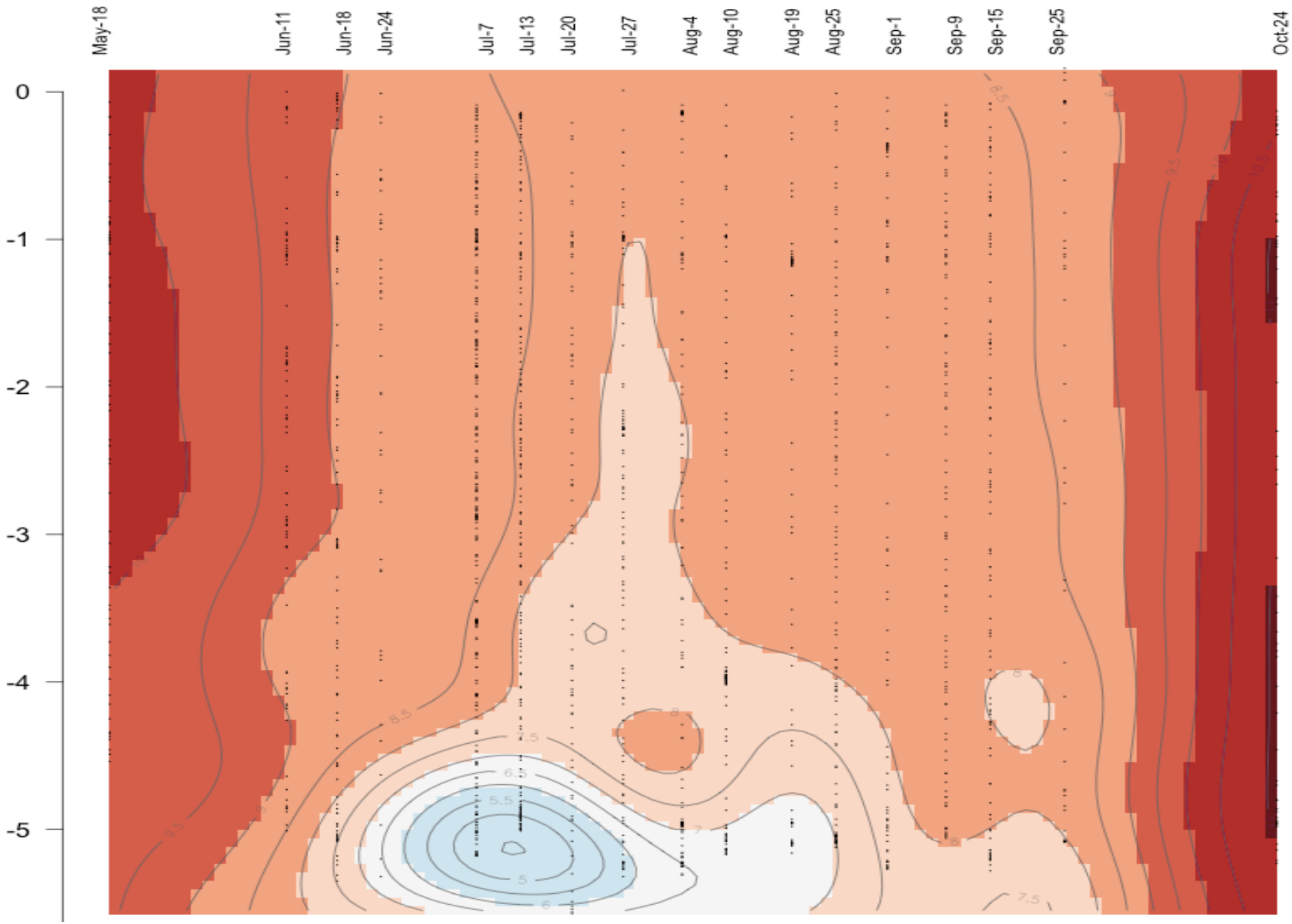
| Depth (M) | % Volume | % Surface Area |
|---|---|---|
| 0.5 | 14.0 | 27.4 |
| 1 | 12.7 | 24.7 |
| 1.5 | 11.7 | 22.6 |
| 2 | 10.8 | 20.8 |
| 2.5 | 10.0 | 19.2 |
| 3 | 9.2 | 17.8 |
| 3.5 | 8.4 | 16.4 |
| 4 | 7.5 | 14.8 |
| 4.5 | 6.4 | 13.1 |
| 5 | 4.8 | 10.8 |
| 5.5 | 2.9 | 7.0 |
| 6 | 1.3 | 3.8 |
| 6.5 | 0.3 | 1.4 |



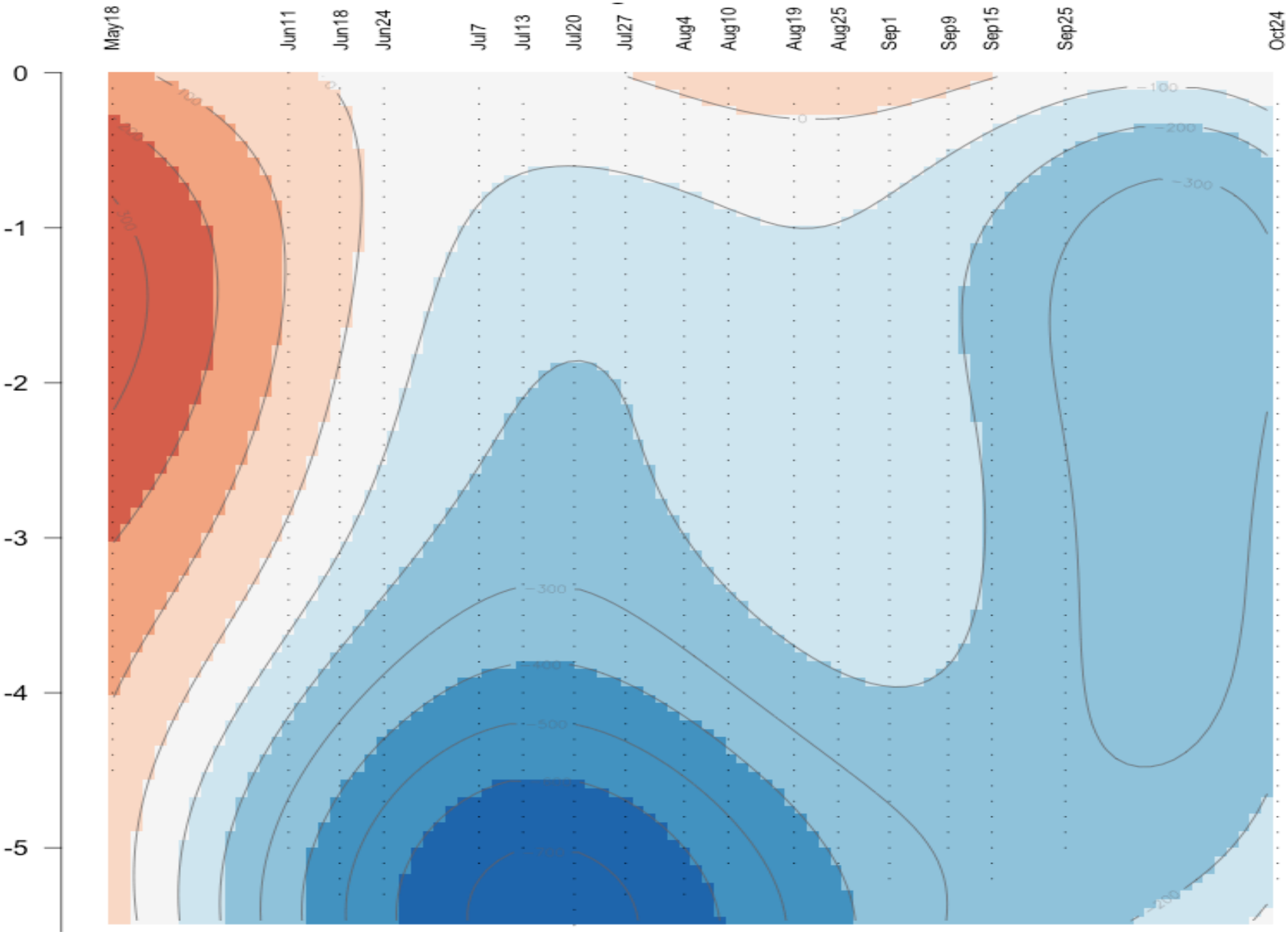
# North Pond Temperature (ºC)

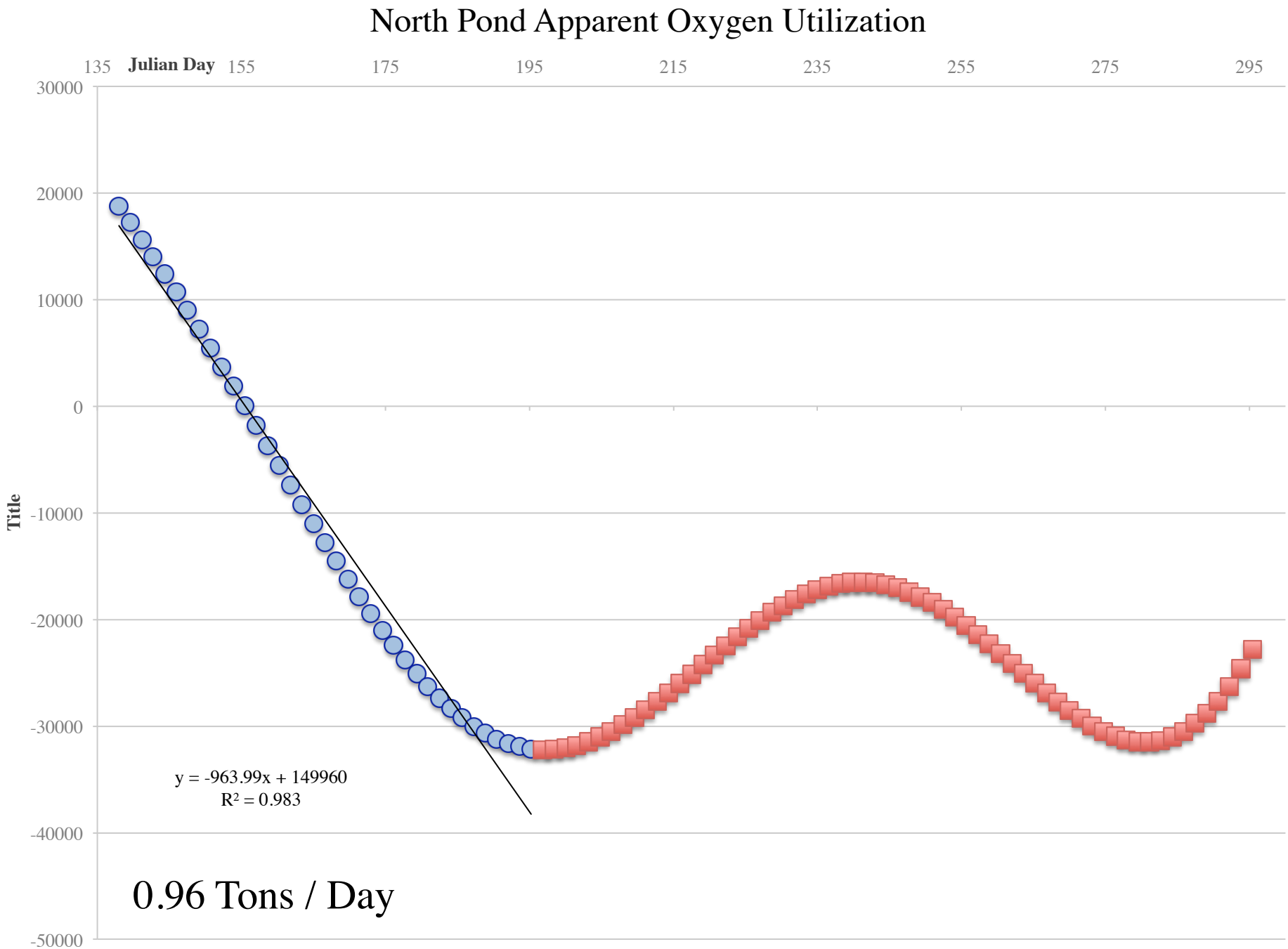


# North Pond Oxygen Concentration (ppm)

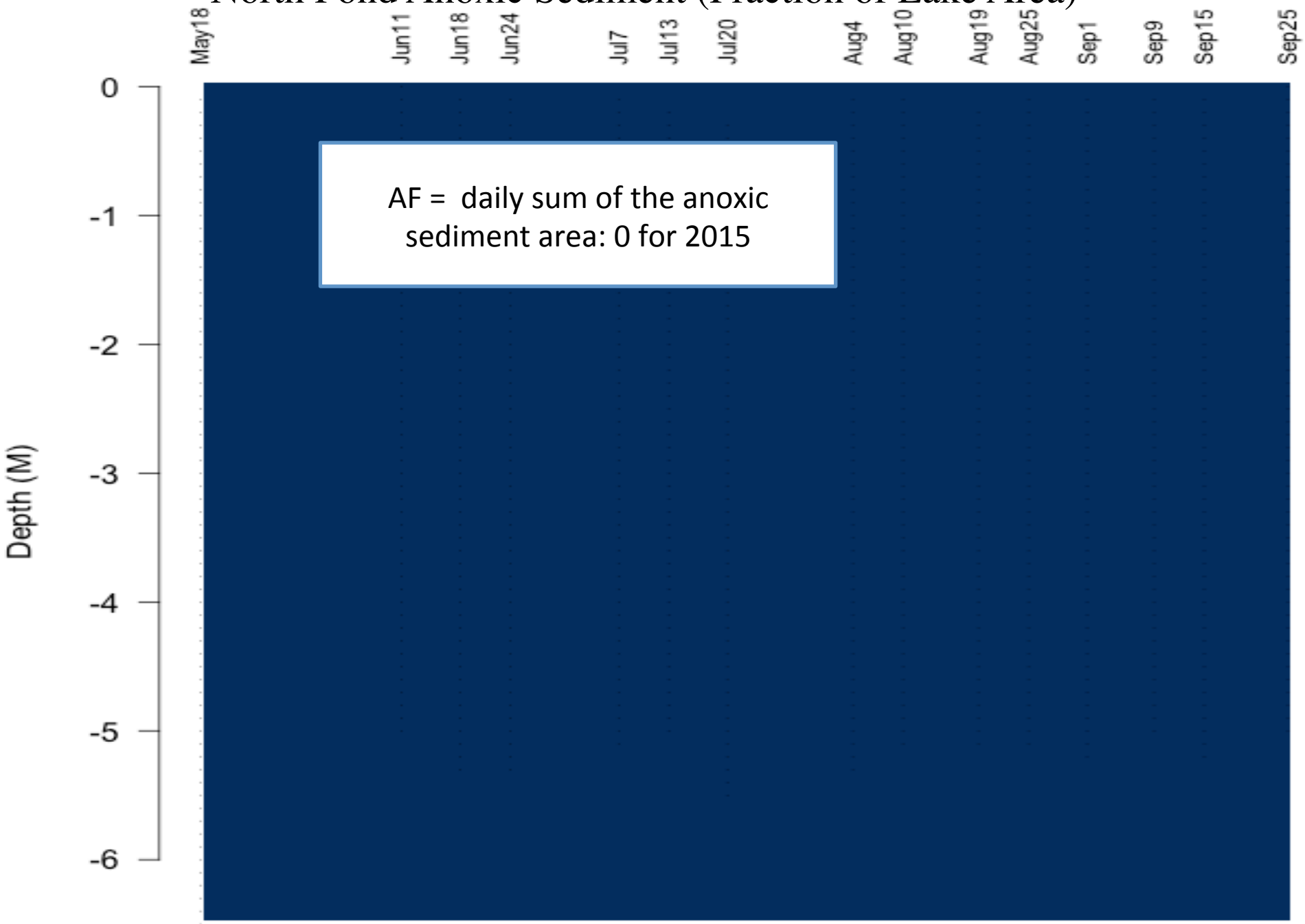


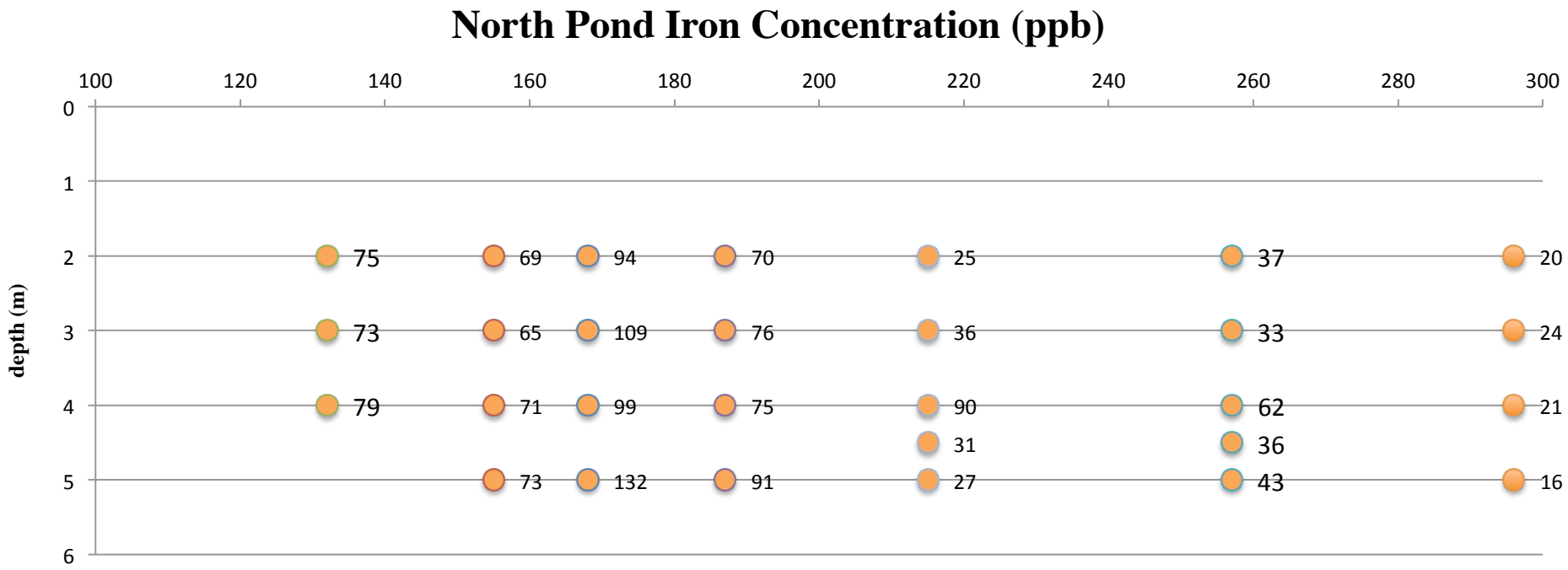
# North Pond Oxygen Anomaly (kg)

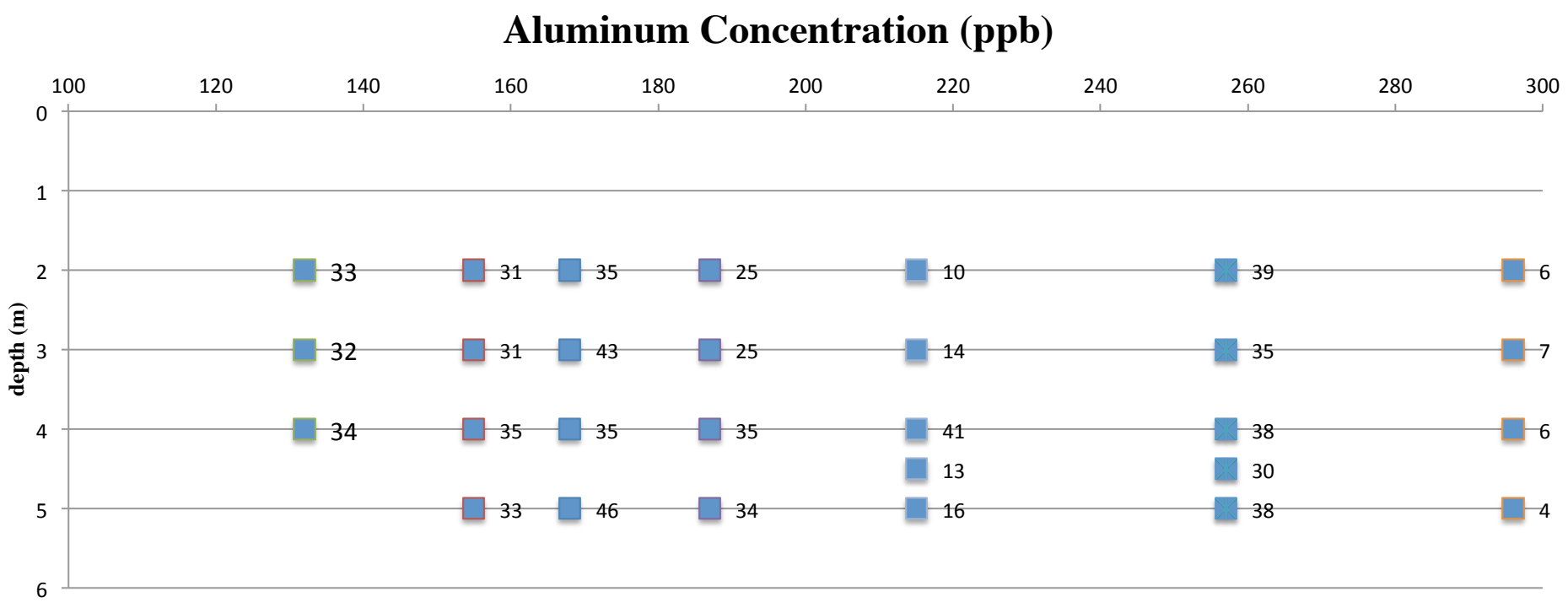


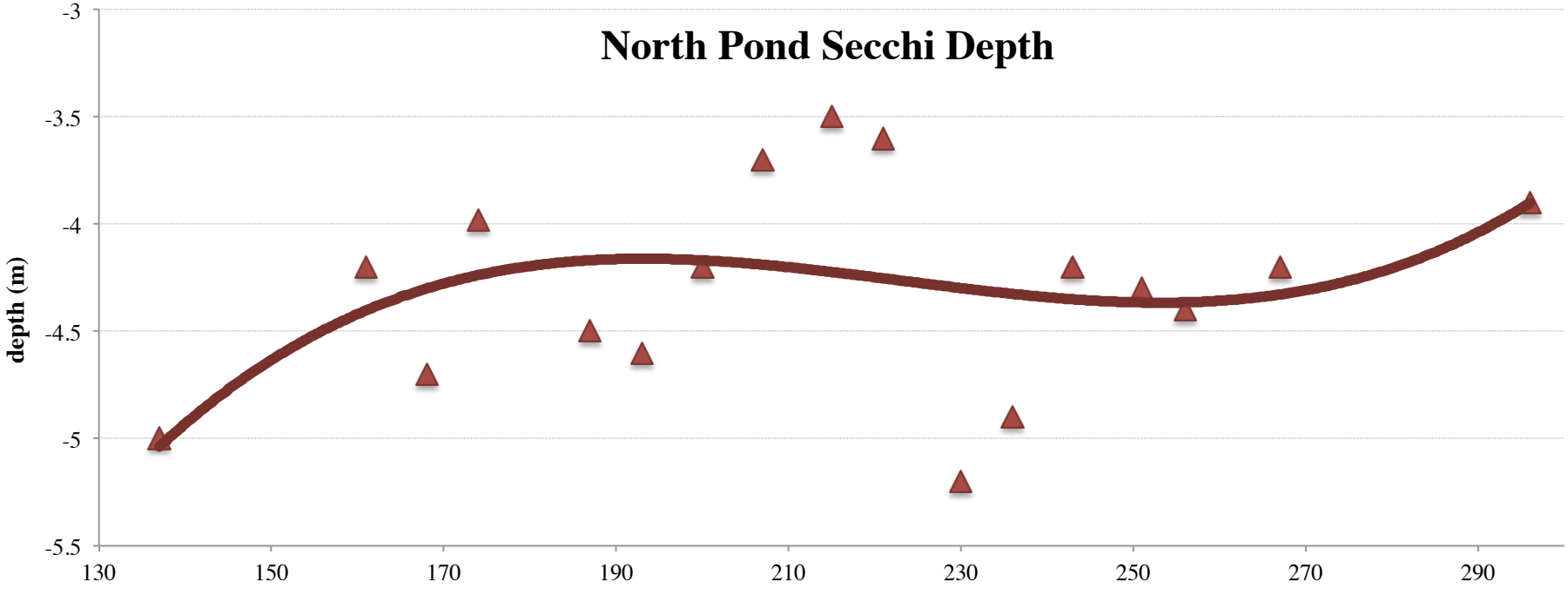

North Pond Apparent Oxygen Utilization
Julian Day
135
155
175
195
215
235
255
275
295
30000
20000
10000
0
-10000
-20000
-30000
-40000
-50000
Title
y = -963.99x + 149960
R² = 0.983
0.96 Tons / Day

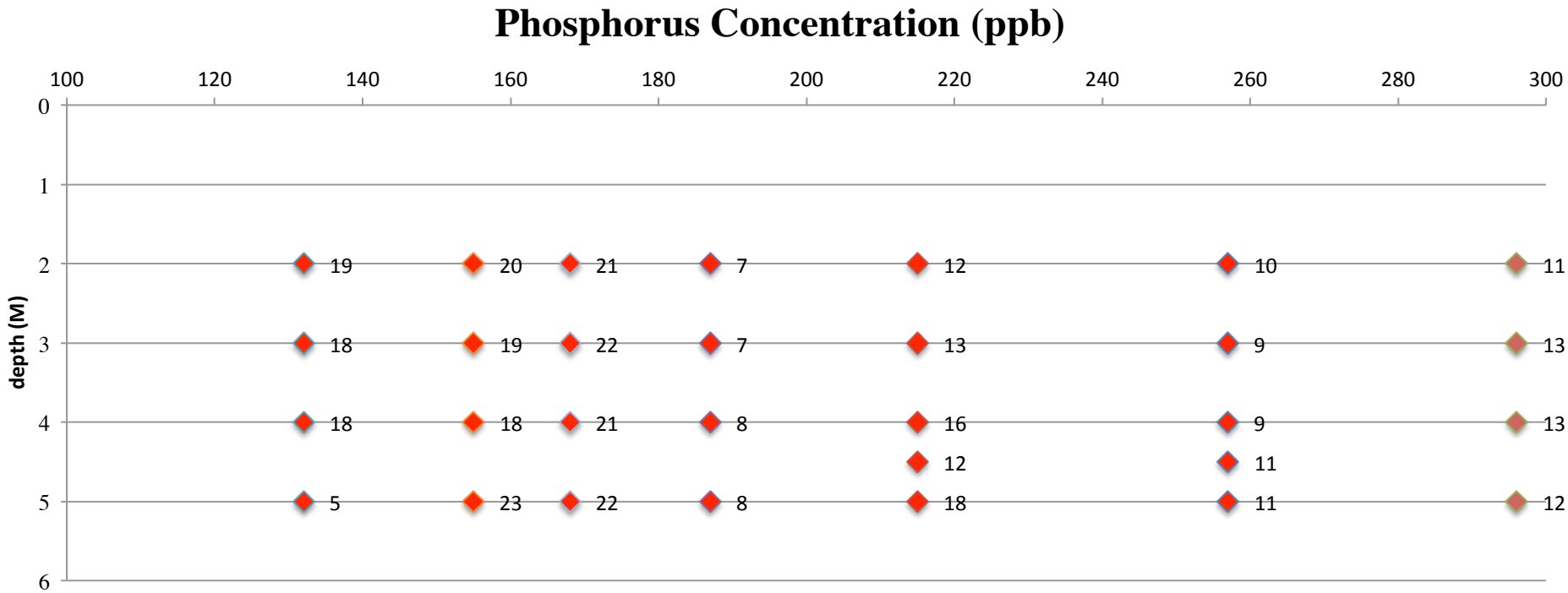
# North Pond Anoxic Sediment (Fraction of Lake Area)



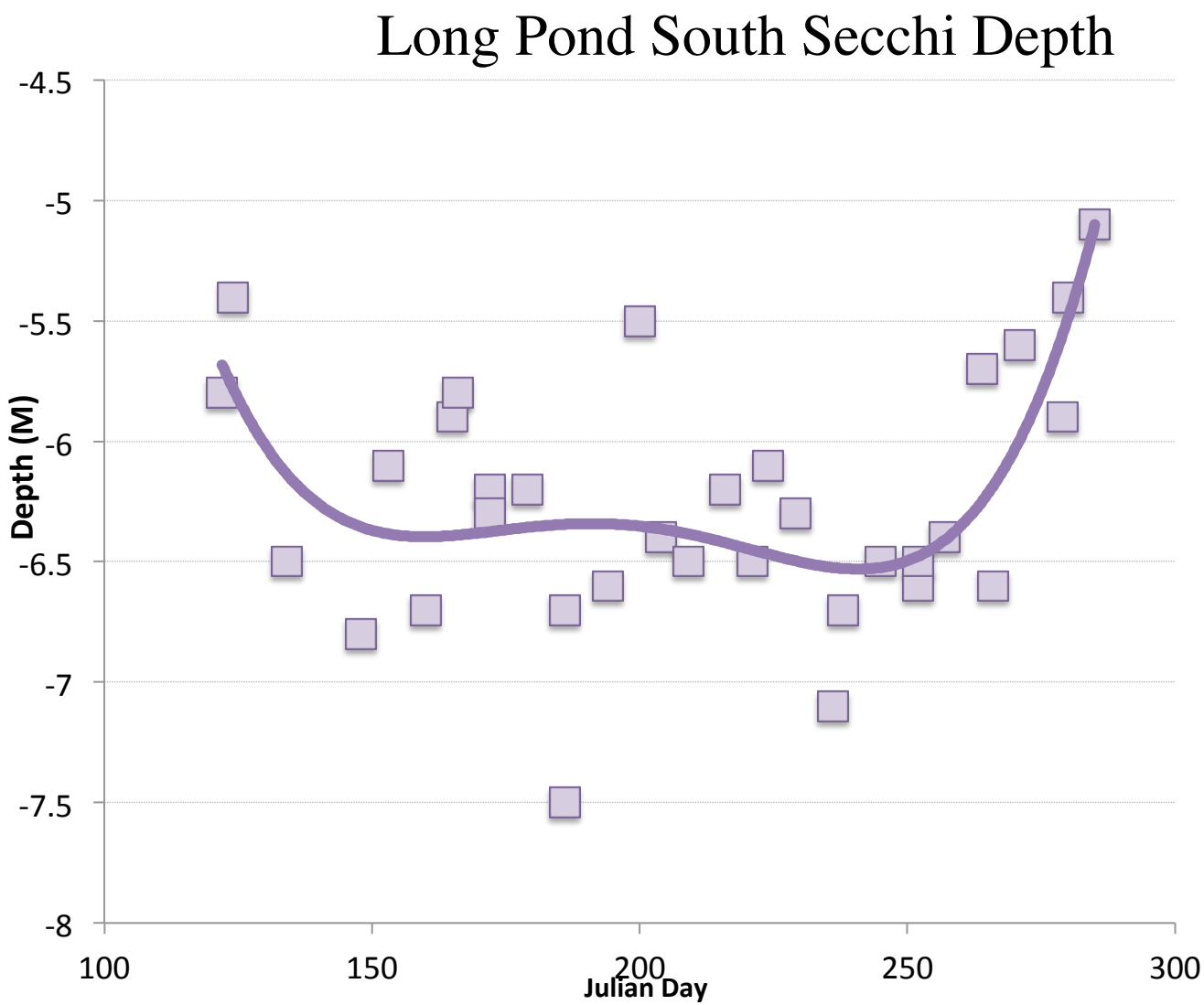

North Pond Iron Concentration (ppb)
depth (m)
100 120 140 160 180 200 220 240 260 280 300
0 1 2 3 4 5 6
75 69 94 70 25 37 20
73 65 109 76 36 33 24
79 71 99 75 90 62 21
31 36
73 132 91 27 43 16


Aluminum Concentration (ppb)
depth (m)
100 120 140 160 180 200 220 240 260 280 300
0 1 2 3 4 5 6
33 31 35 25 10 39 6
32 31 43 25 14 35 7
34 35 35 35 41 38 6
13 30
33 46 34 16 38 4


North Pond Secchi Depth
depth (m)
-3
-3.5
-4
-4.5
-5
-5.5
130
150
170
190
210
230
250
270
290

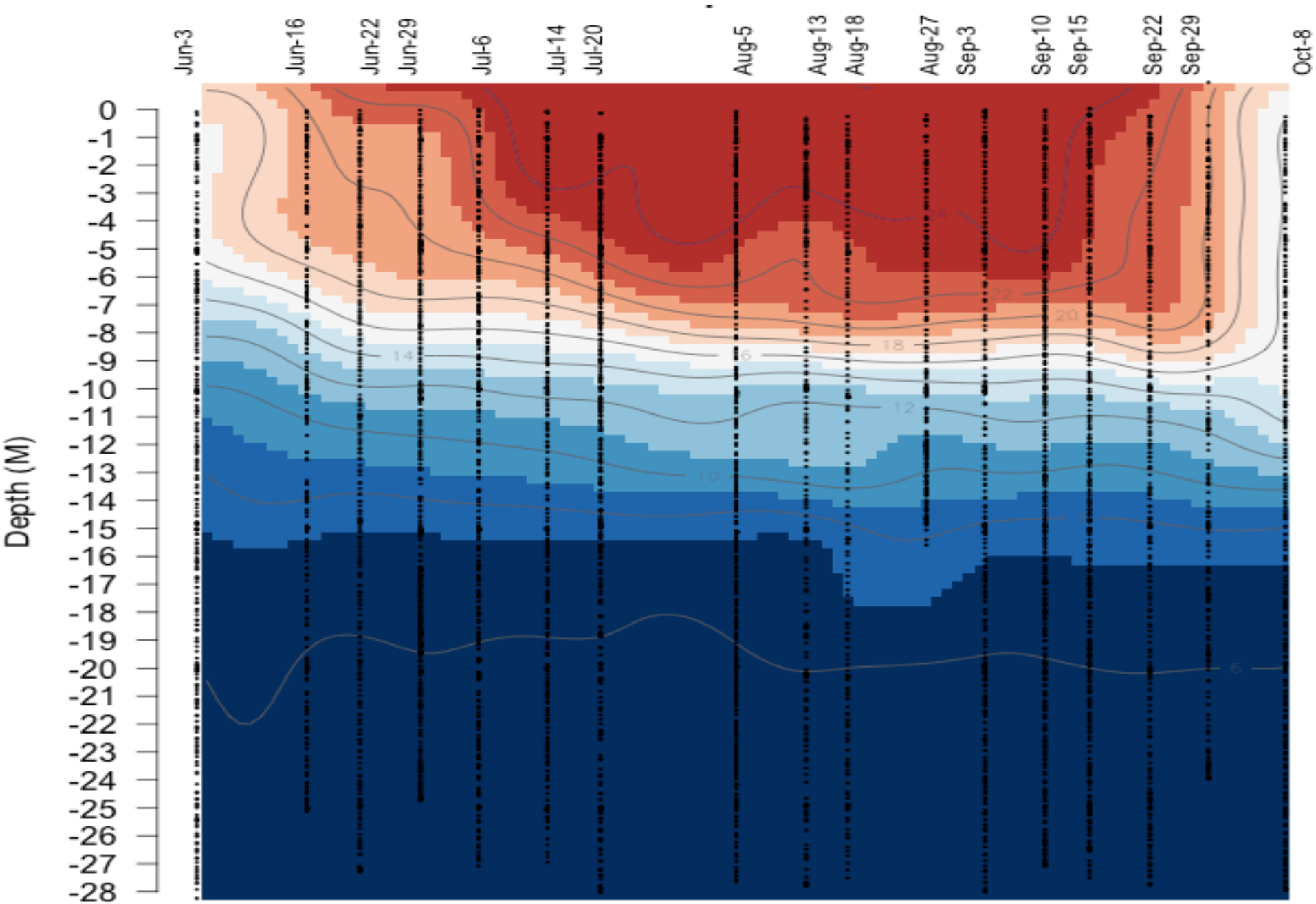

Phosphorus Concentration (ppb)
depth (M)
100
120
140
160
180
200
220
240
260
280
300
0
1
2
3
4
5
6
19
20
21
7
12
10
11
18
19
22
7
13
9
13
18
18
21
8
16
9
13
12
11
5
23
22
8
18
11
12

| Depth (M) | % Volume | % Surface Area |
|---|---|---|
| 0 | 13.27 | 12.43 |
| 1 | 12.44 | 12.43 |
| 2 | 10.98 | 10.89 |
| 3 | 9.74 | 9.70 |
| 4 | 8.62 | 8.57 |
| 5 | 7.56 | 7.59 |
| 6 | 6.46 | 6.58 |
| 7 | 5.36 | 5.54 |
| 8 | 4.28 | 4.53 |
| 9 | 3.32 | 3.51 |
| 10 | 2.66 | 2.73 |
| 11 | 2.17 | 2.27 |
| 12 | 1.76 | 1.80 |
| 13 | 1.50 | 1.49 |
| 14 | 1.34 | 1.33 |
| 15 | 1.20 | 1.18 |
| 16 | 1.07 | 1.06 |
| 17 | 0.96 | 0.95 |
| 18 | 0.86 | 0.85 |
| 19 | 0.77 | 0.76 |
| 20 | 0.70 | 0.69 |
| 21 | 0.63 | 0.62 |
| 22 | 0.56 | 0.55 |
| 23 | 0.49 | 0.49 |
| 24 | 0.41 | 0.42 |
| 25 | 0.34 | 0.35 |
| 26 | 0.25 | 0.28 |
| 27 | 0.16 | 0.20 |
| 28 | 0.08 | 0.11 |
| 29 | 0.04 | 0.05 |
| 30 | 0.01 | 0.02 |
| 31 | 0.00 | 0.01 |

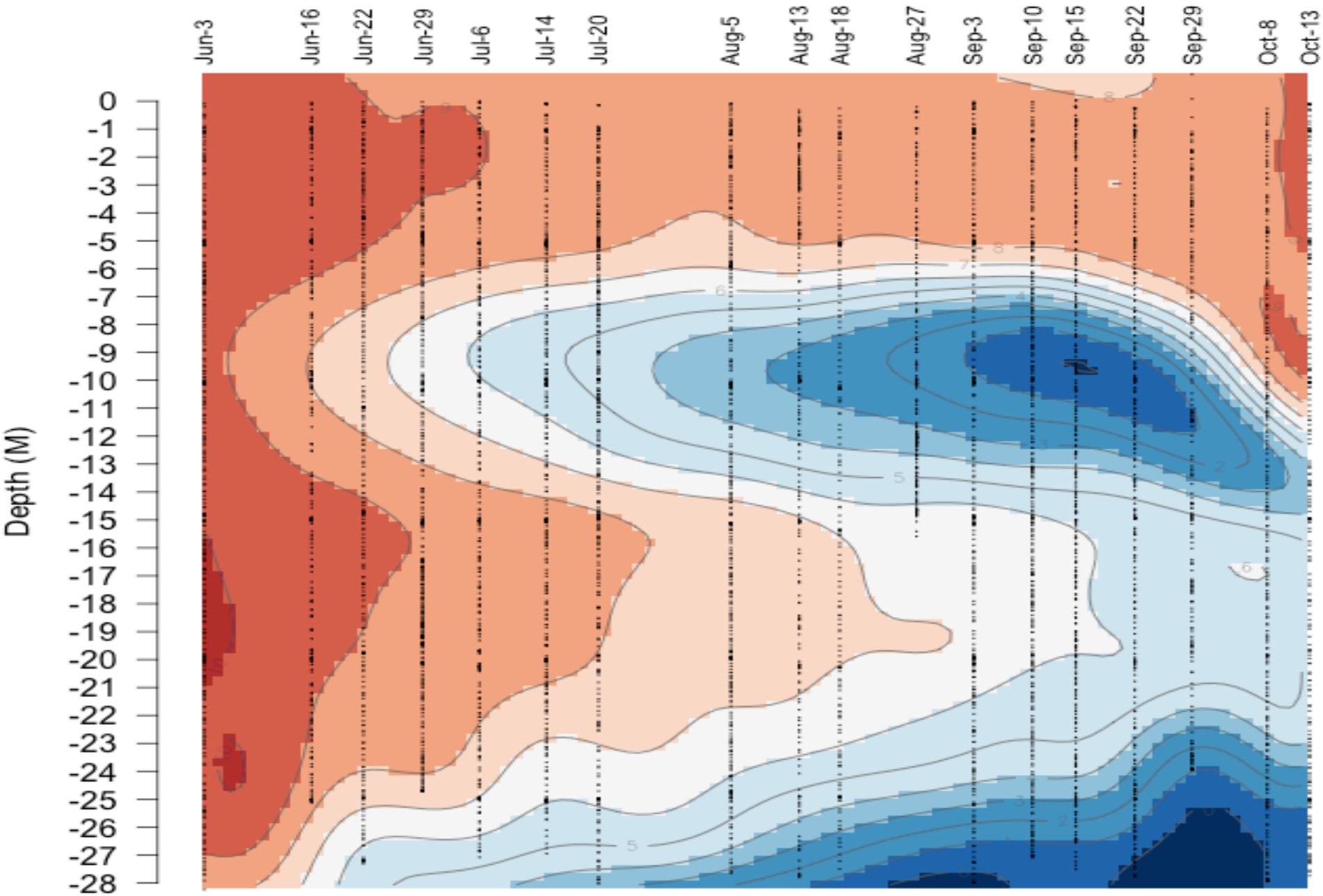



| | | | |
|---|---|---|---|
| Area ($km^2$) | 4.11 | $O_2$ Loss Rate (metric tons/day) | 0.24 |
| Volume (millions $m^3$) | 30.96 | Flushing Rate (#/year) | 3.5 |
| Mean Depth (m) | 7.53 | | |
| Morphometric Ratio | 3.32 | Days Sampled | 18 |
| Thermocline Depth (m) | 6 | Number of Samples | 5,917 |
| Anoxic Factor (lake area * days) | 3.81 | Secchi Mean (M) | 6.2 |

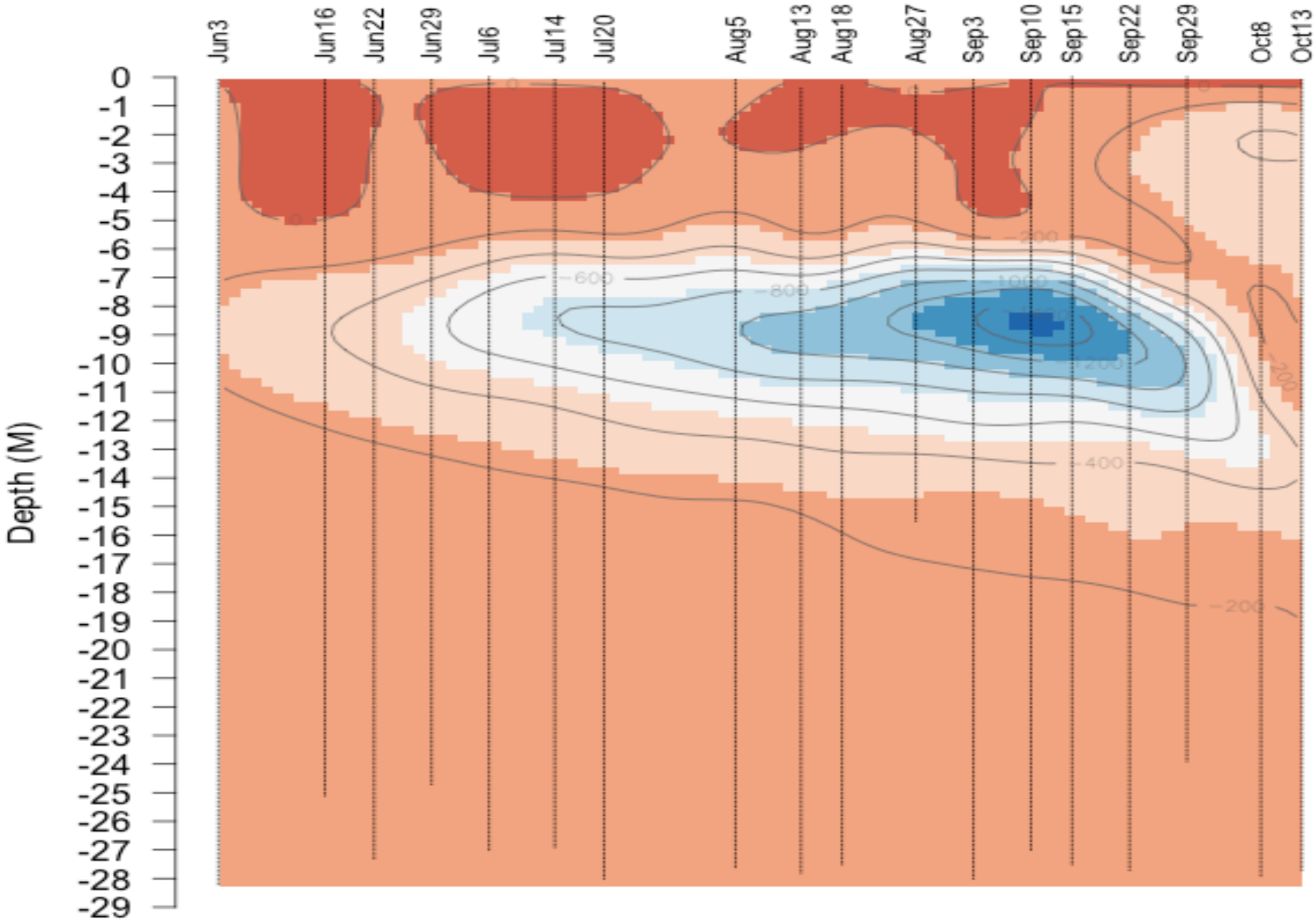
South Long Pond Temperature (ºC)

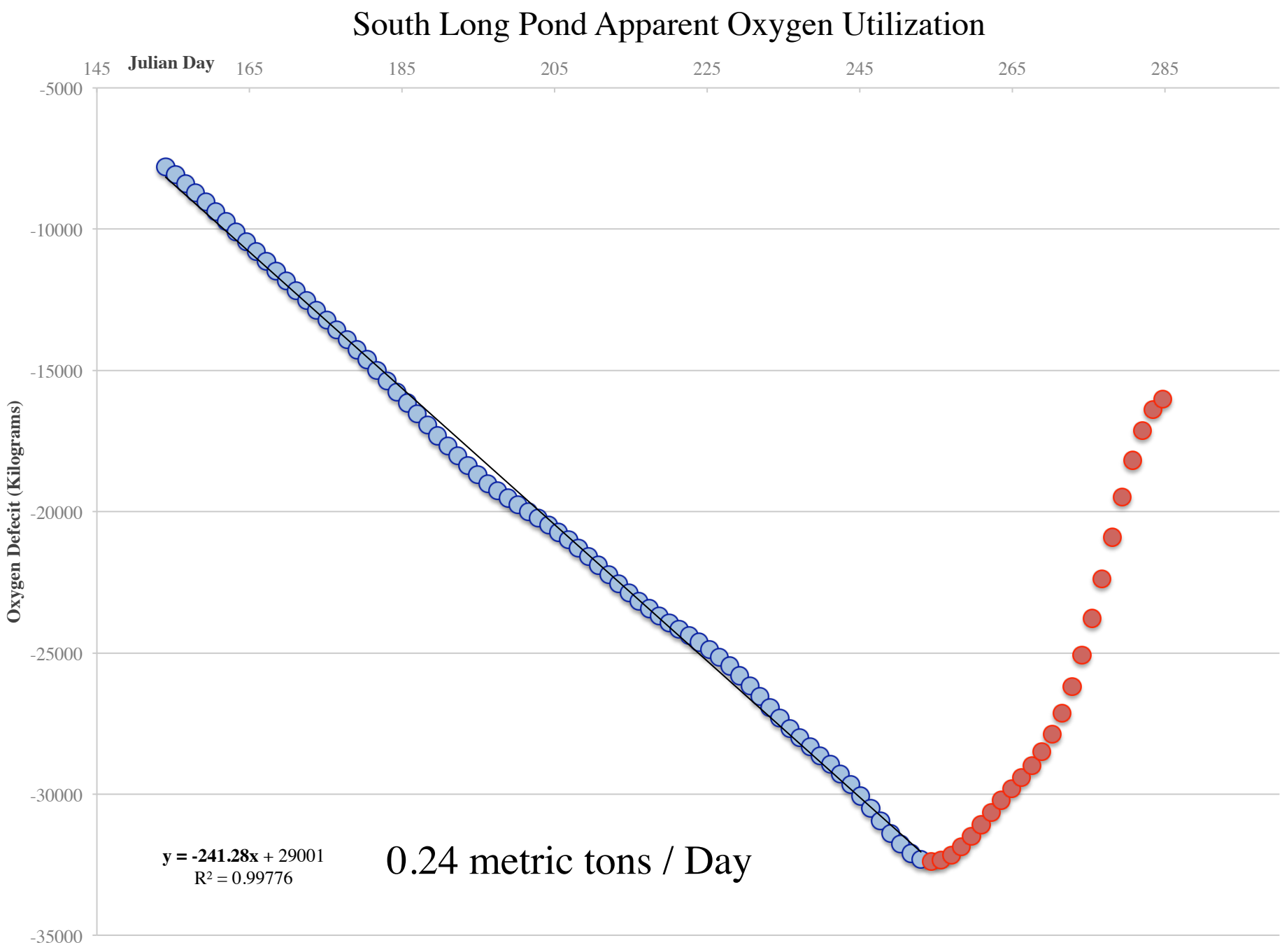


South Long Pond Oxygen Concentration (ppm)

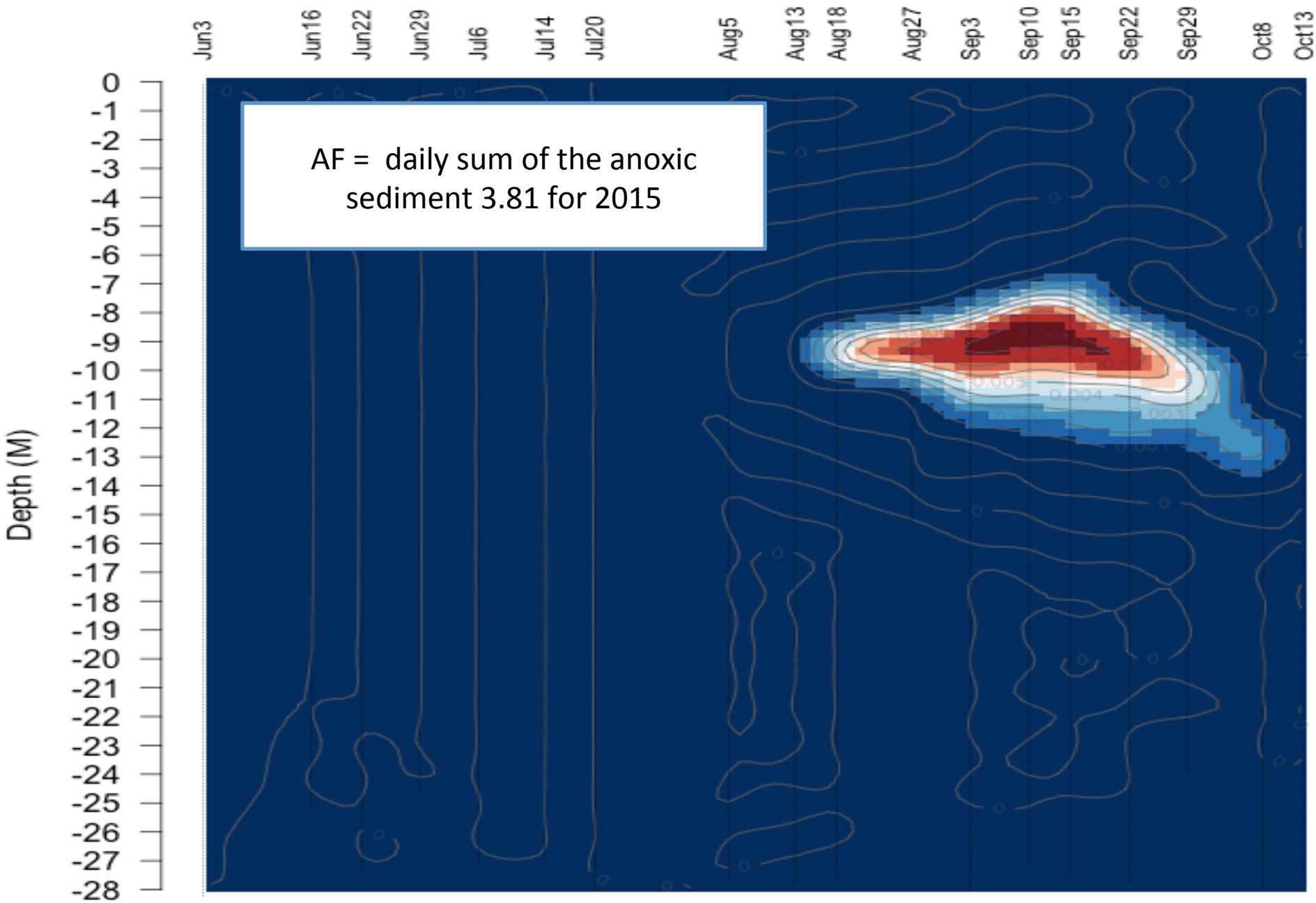


South Long Pond Oxygen Anomaly (kg)

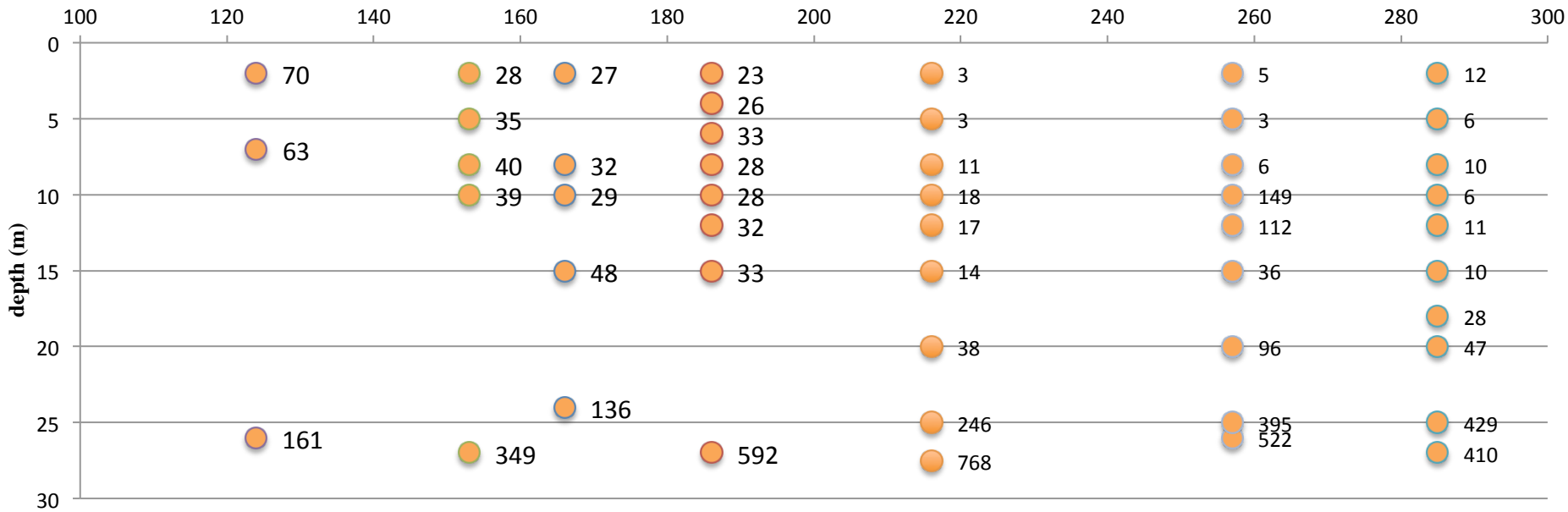



South Long Pond Apparent Oxygen Utilization
Julian Day
145
165
185
205
225
245
265
285
-5000
-10000
-15000
-20000
-25000
-30000
-35000
Oxygen Defecit (Kilograms)
y = -241.28x + 29001
R² = 0.99776
0.24 metric tons / Day

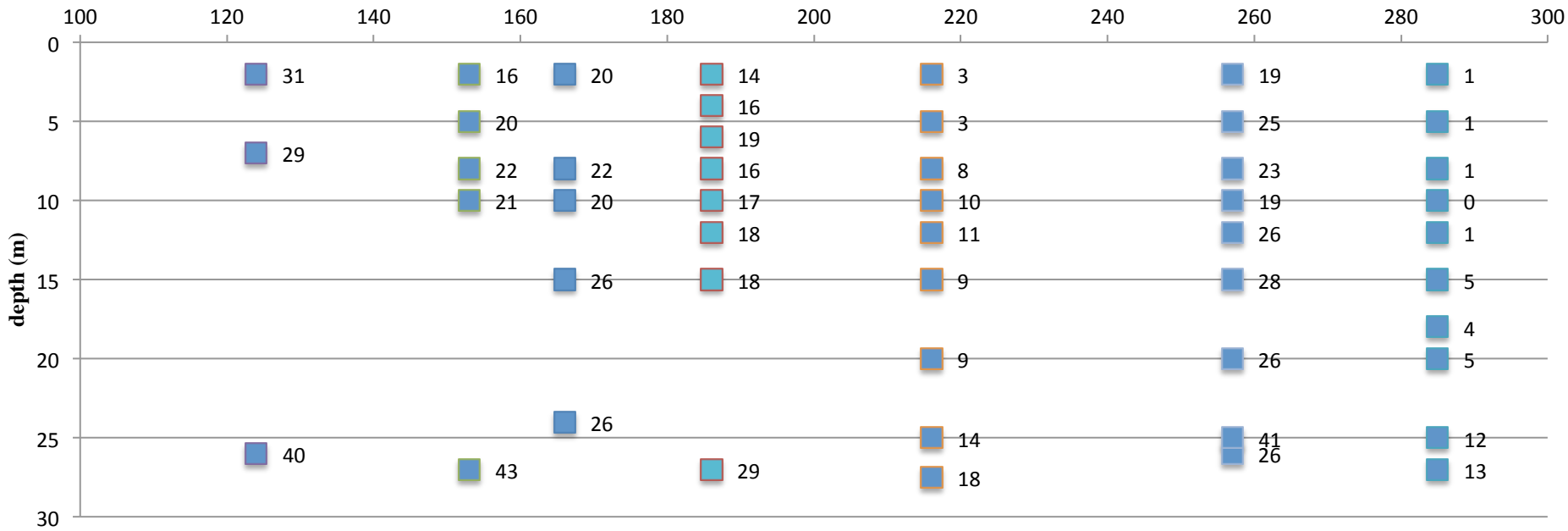
# South Long Pond Anoxic Sediment (Fraction of Lake Area)



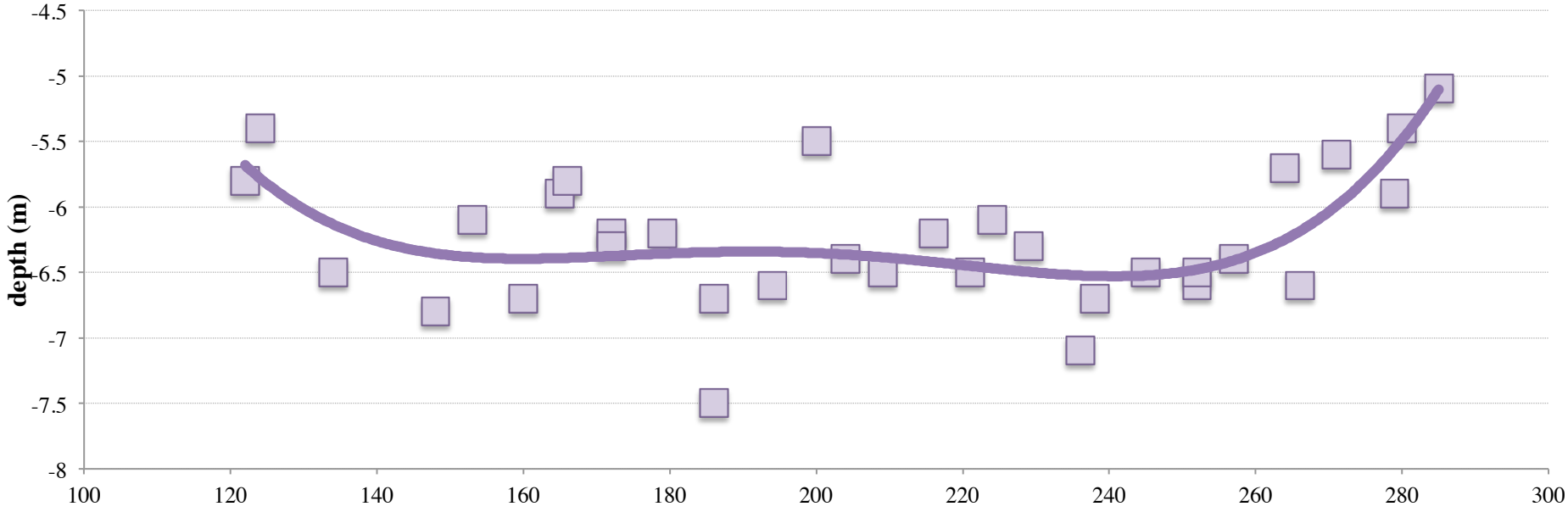
# Long Pond South Iron Concentration (ppb)



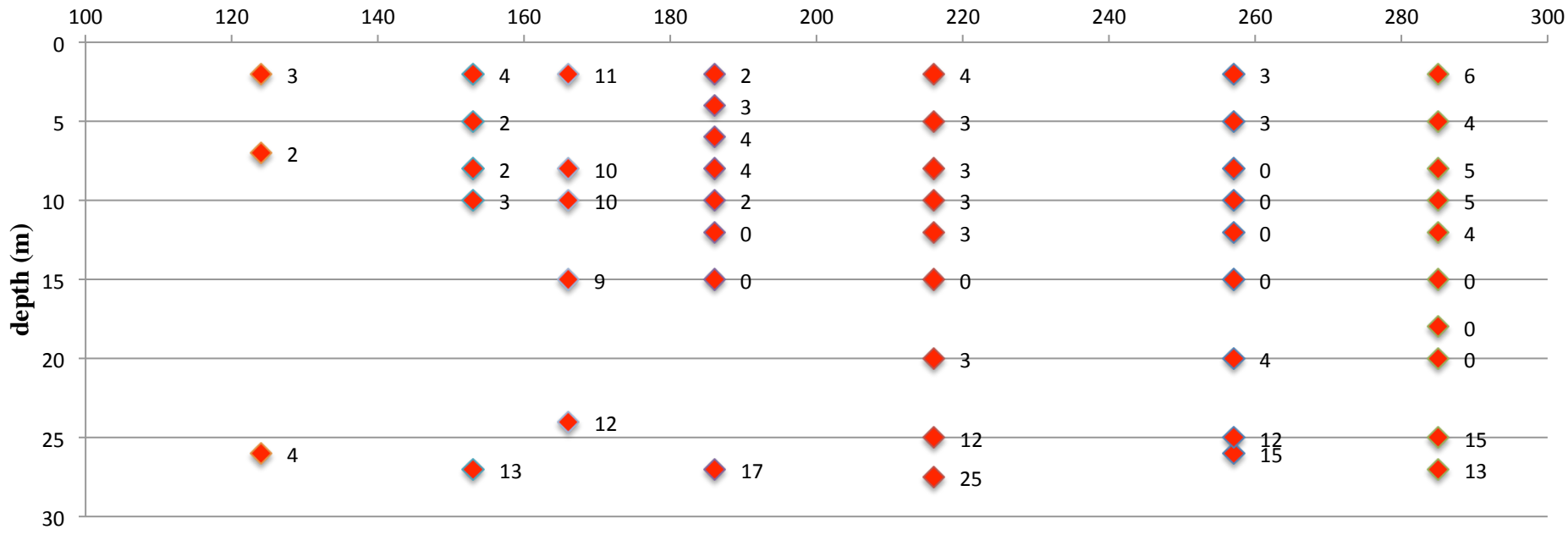

# Aluminum Concentration (ppb)



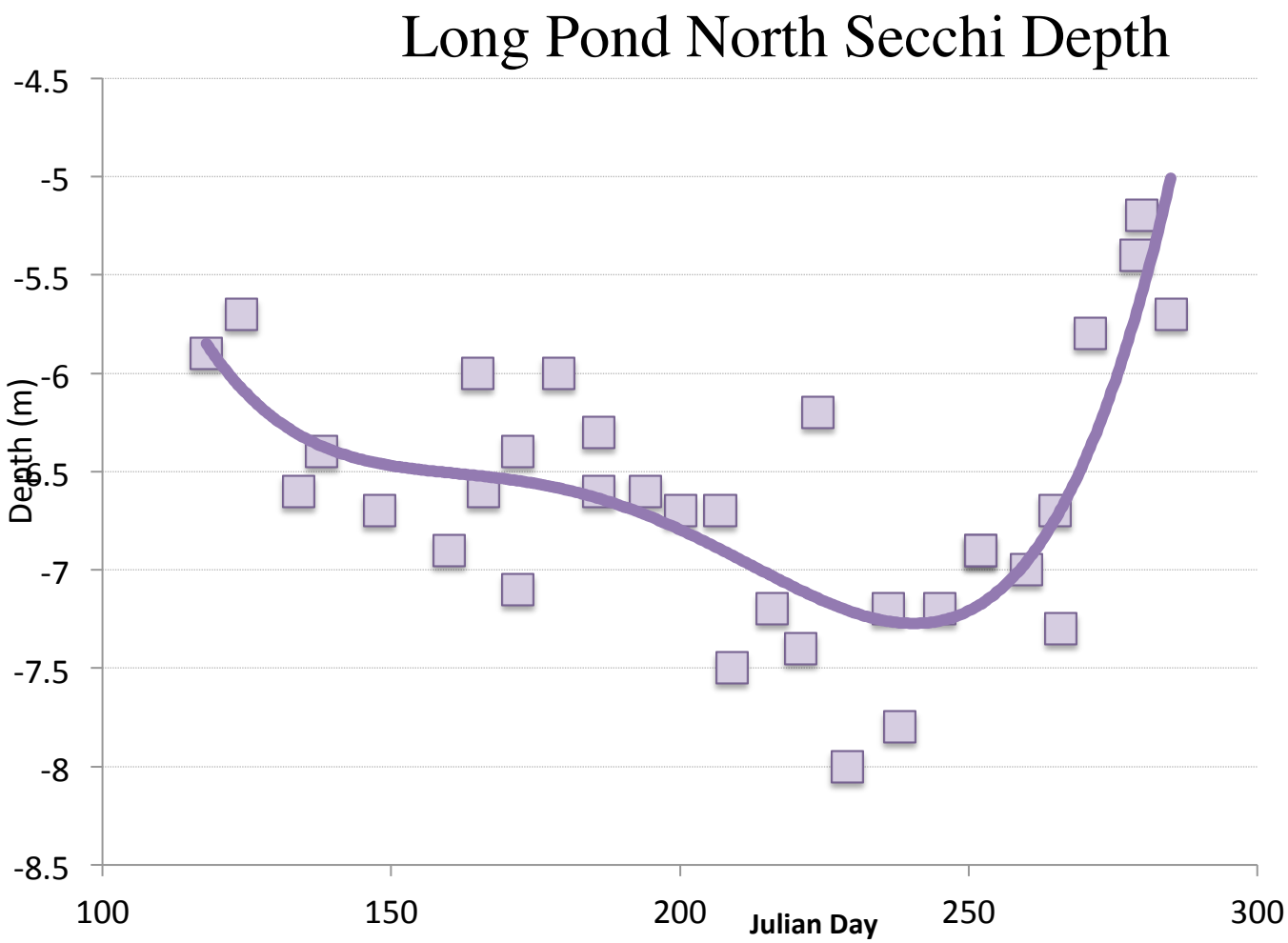
# Long Pond South Secchi Depth




# Phosphorus Concentration (ppb)



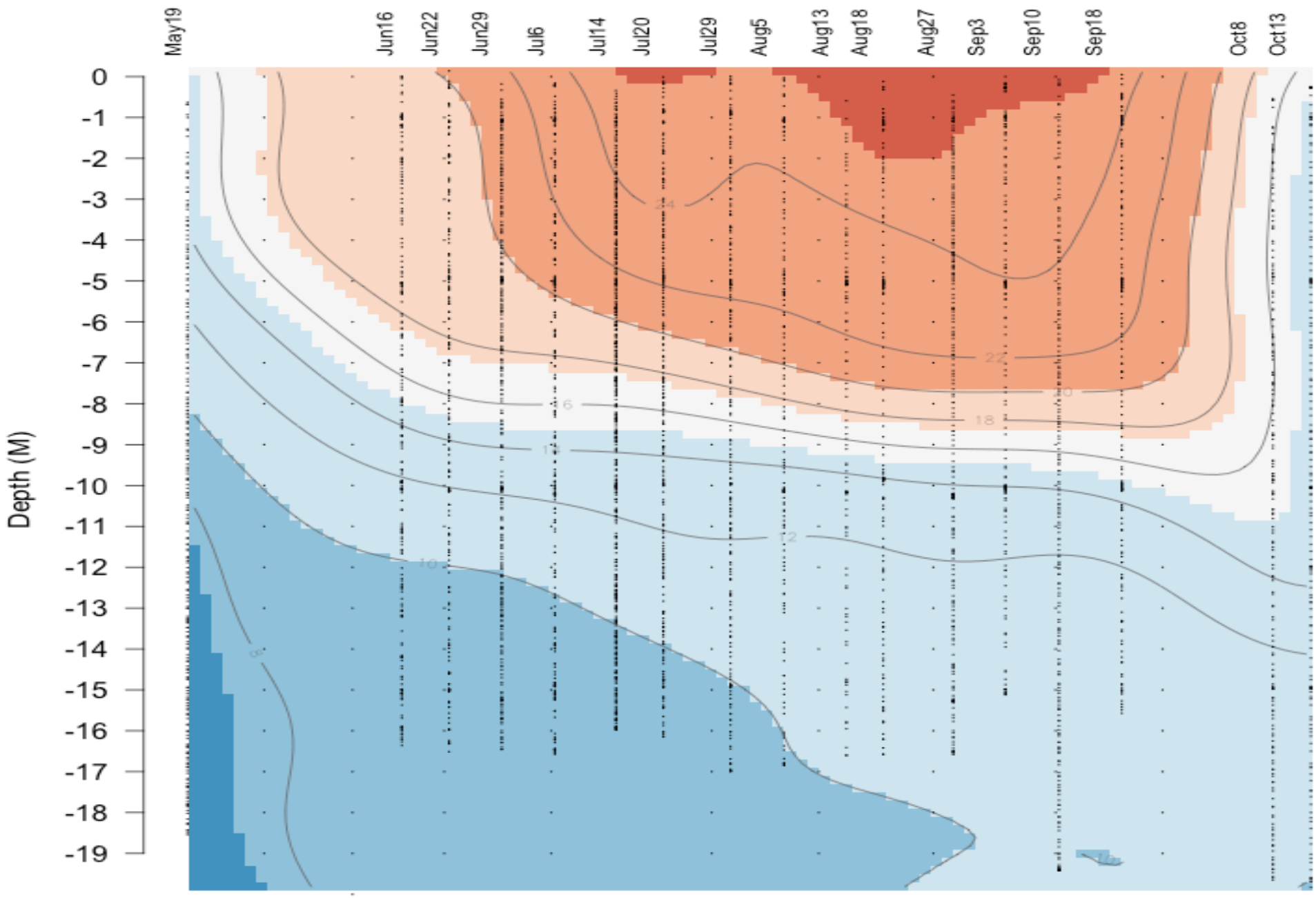
| Depth (M) | % Volume | % Surface Area |
|---|---|---|
| 0 | 13.29 | 12.44 |
| 1 | 12.46 | 12.44 |
| 2 | 11.12 | 10.91 |
| 3 | 10.12 | 9.92 |
| 4 | 9.14 | 9.04 |
| 5 | 8.13 | 8.08 |
| 6 | 7.18 | 7.15 |
| 7 | 6.27 | 6.30 |
| 8 | 5.44 | 5.45 |
| 9 | 4.62 | 4.74 |
| 10 | 3.73 | 3.93 |
| 11 | 2.82 | 3.07 |
| 12 | 2.06 | 2.23 |
| 13 | 1.43 | 1.63 |
| 14 | 0.97 | 1.07 |
| 15 | 0.68 | 0.75 |
| 16 | 0.44 | 0.53 |
| 17 | 0.12 | 0.30 |
| 18 | 0.00 | 0.01 |
| 19 | 0.00 | 0.00 |
| 20 | 0.00 | 0.00 |
| 21 | 0.00 | 0.00 |
| 22 | 0.00 | 0.00 |
| 23 | 0.00 | 0.00 |
| 24 | 0.00 | 0.00 |
| 25 | 0.00 | 0.00 |
| 26 | 0.00 | 0.00 |
| 27 | 0.00 | 0.00 |
| 28 | 0.00 | 0.00 |
| 29 | 0.00 | 0.00 |
| 30 | 0.00 | 0.00 |
| 31 | 0.00 | 0.00 |



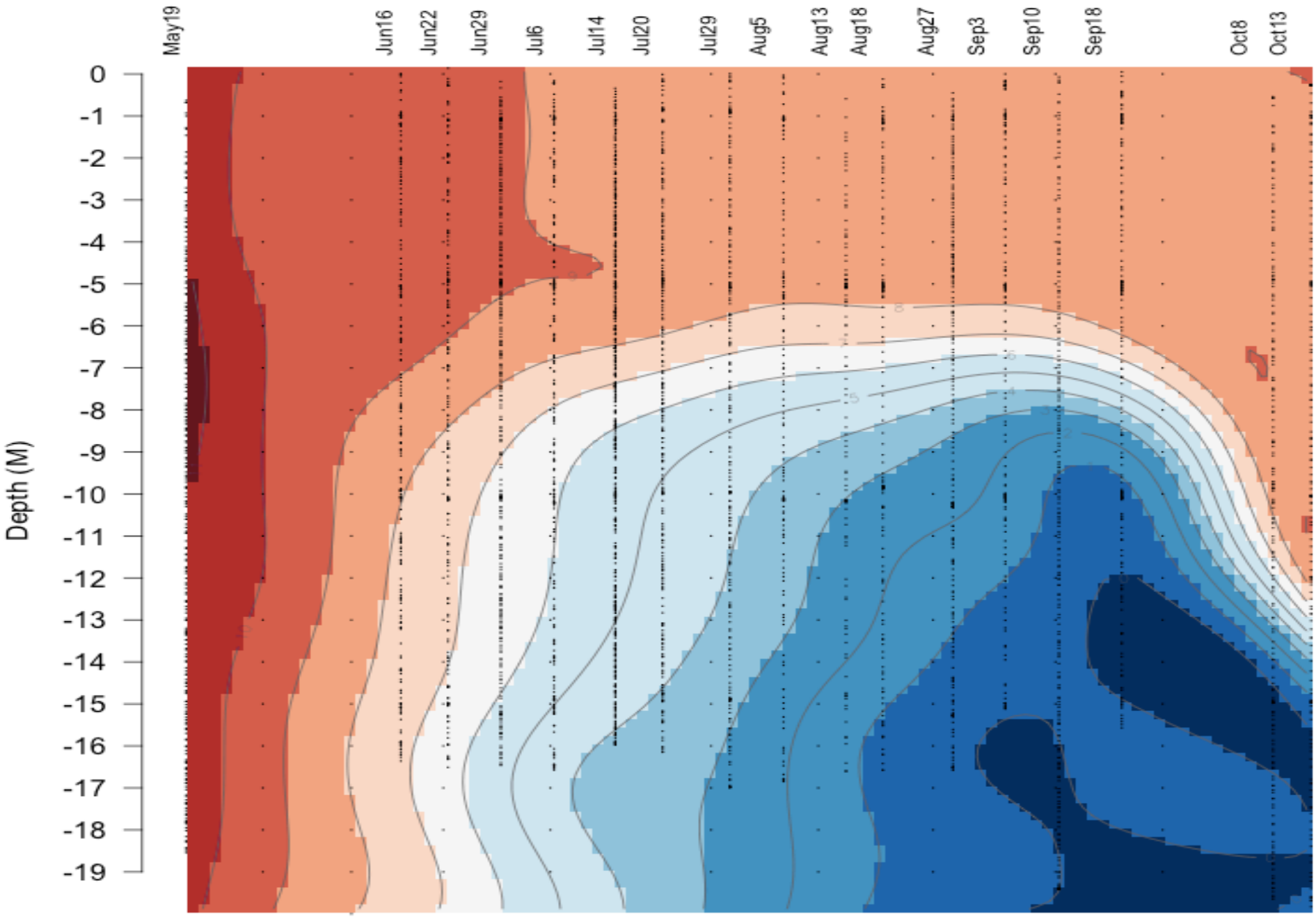

| | | | |
|---|---|---|---|
| Area ($km^2$) | 10.35 | $O_2$ Loss Rate (metric tons/day) | 0.48 |
| Volume (millions $m^3$) | 90.2 | Flushing Rate (#/year) | 3.5 |
| Mean Depth (m) | 10.67 | | |
| Morphometric Ratio | 3.32 | Days Sampled | 23 |
| Thermocline Depth (m) | 6.5 | Number of Samples | 4,2617 |
| Anoxic Factor (lake area * days) | 5.67 | Secchi Mean (M) | 6.6 |

# Long Pond North

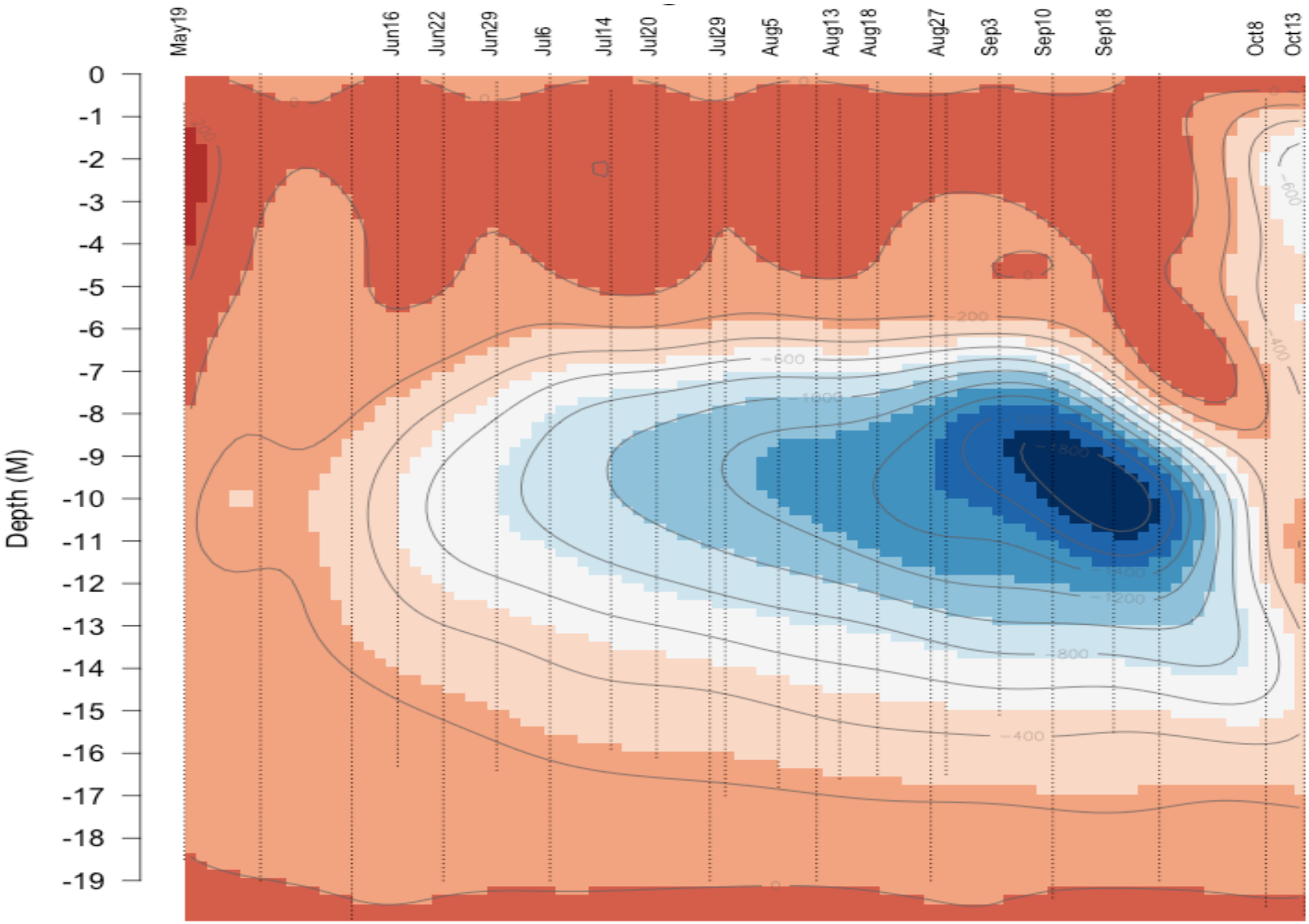
# Long Pond North Temperature (ºC)

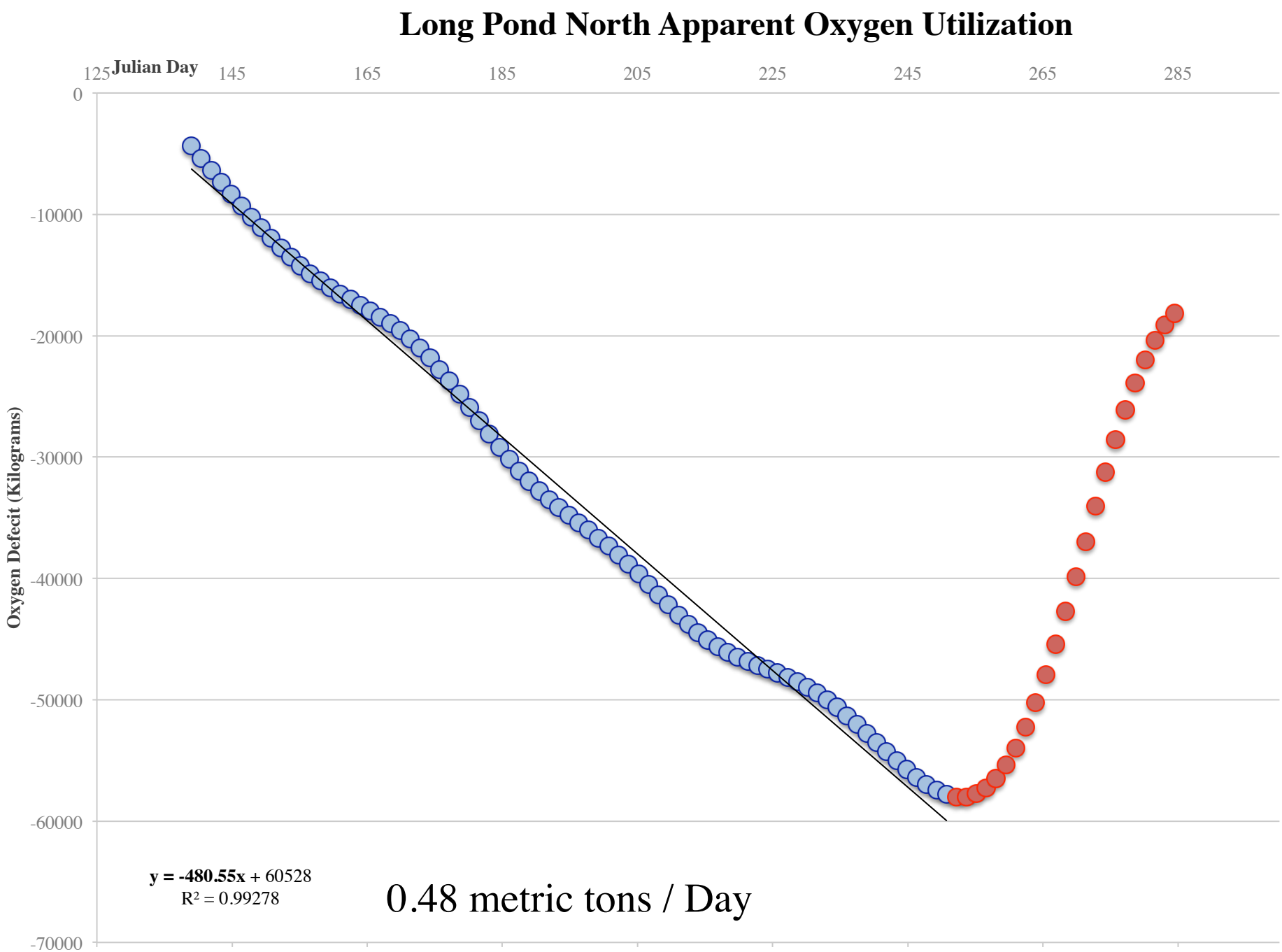


# Long Pond North Oxygen Saturation (ppm)

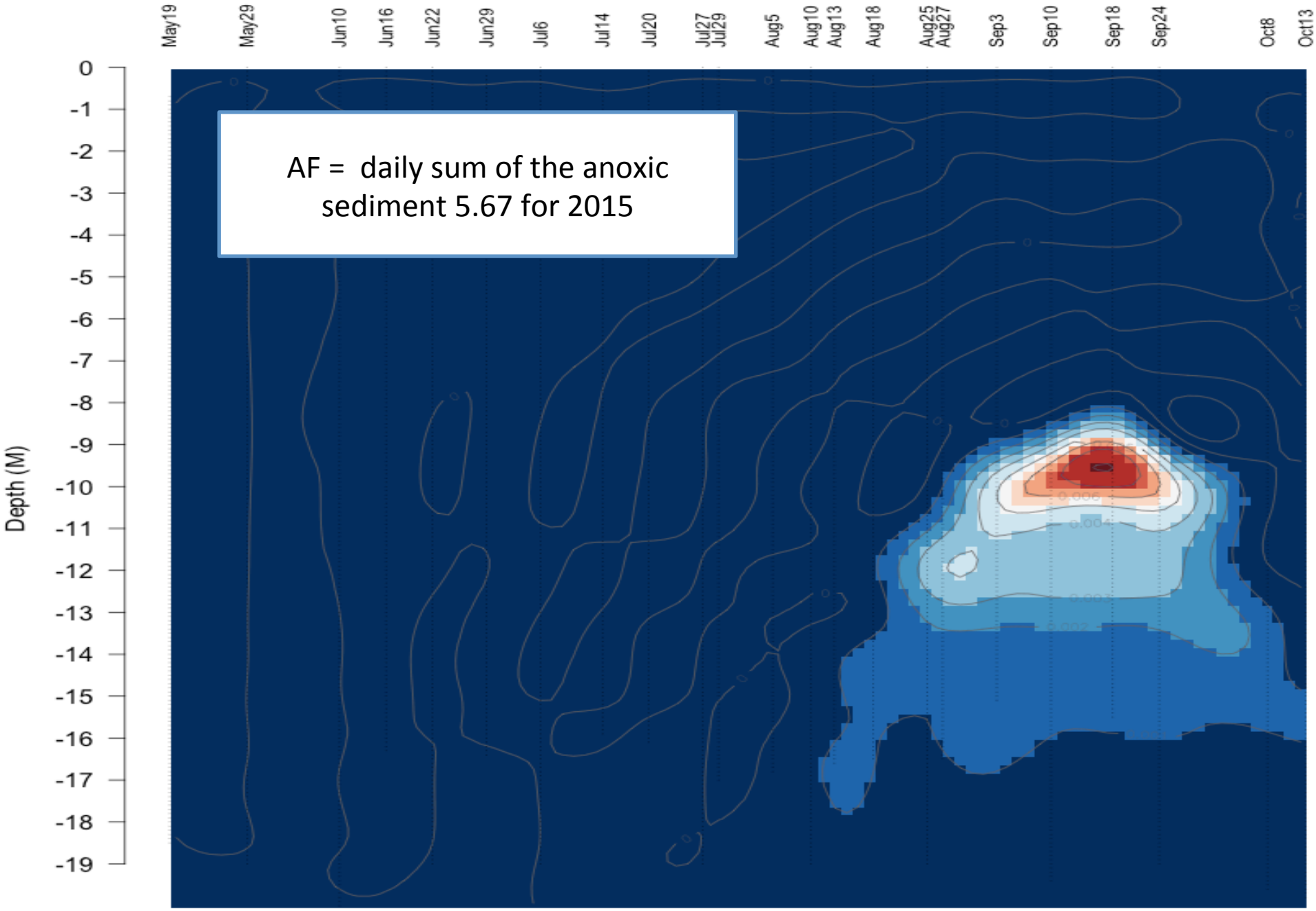


# Long Pond North Oxygen Anomaly (kg)

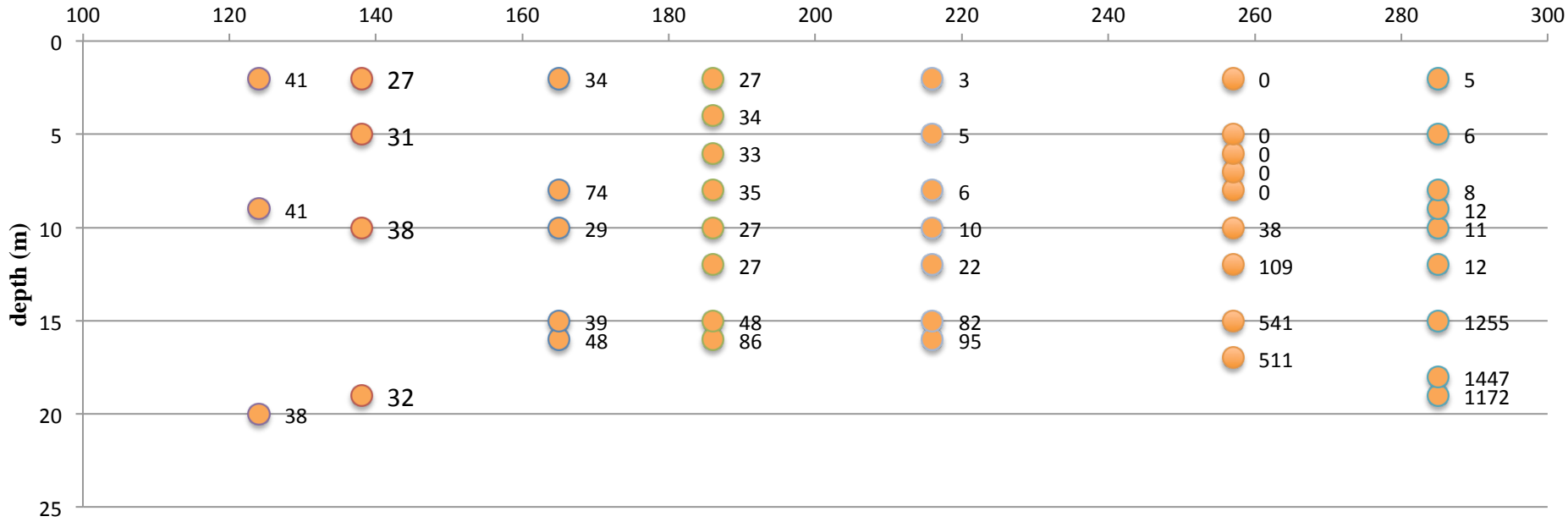



Long Pond North Apparent Oxygen Utilization
Julian Day
125
145
165
185
205
225
245
265
285
0
-10000
-20000
-30000
-40000
-50000
-60000
-70000
Oxygen Defecit (Kilograms)
y = -480.55x + 60528
R² = 0.99278
0.48 metric tons / Day

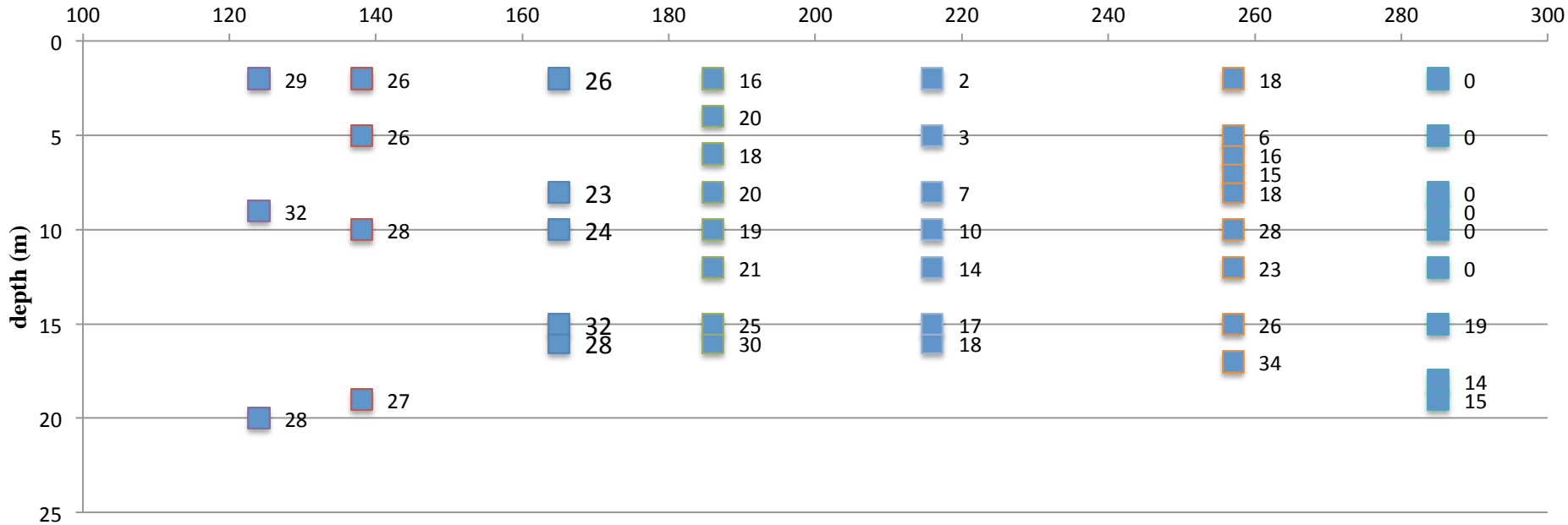
# Long Pond North Anoxic Sediment (Fraction of Lake Area)

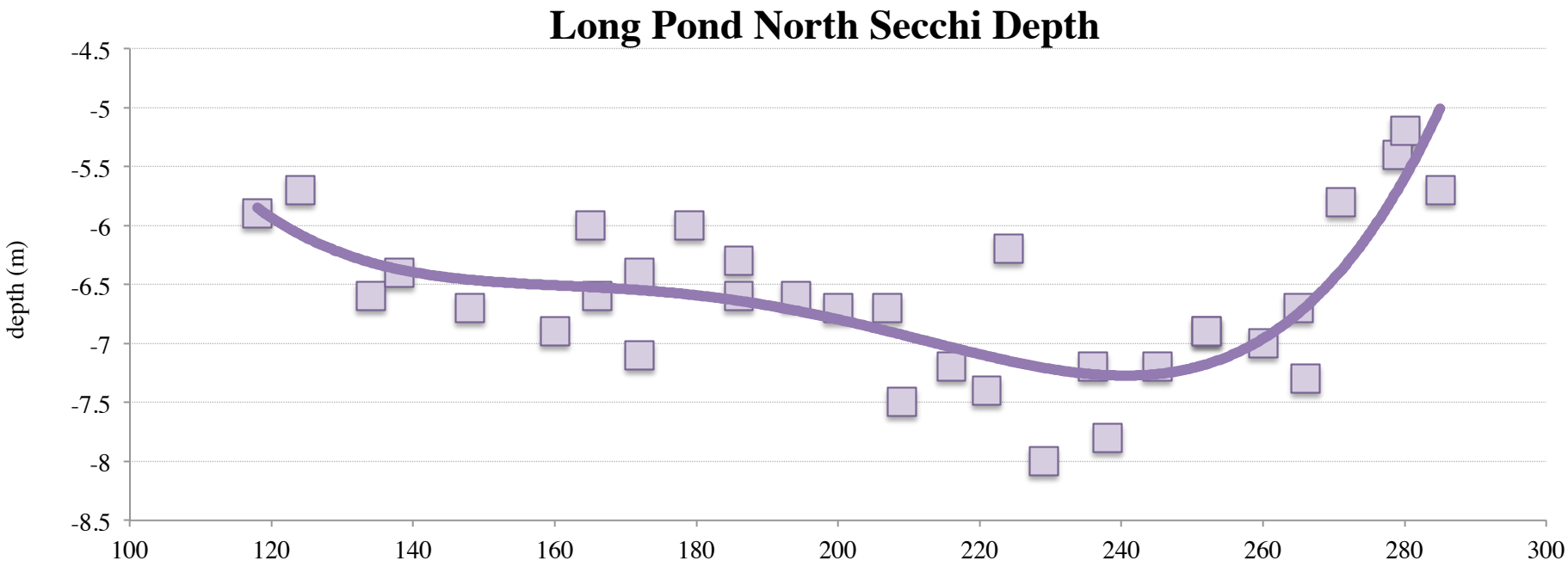


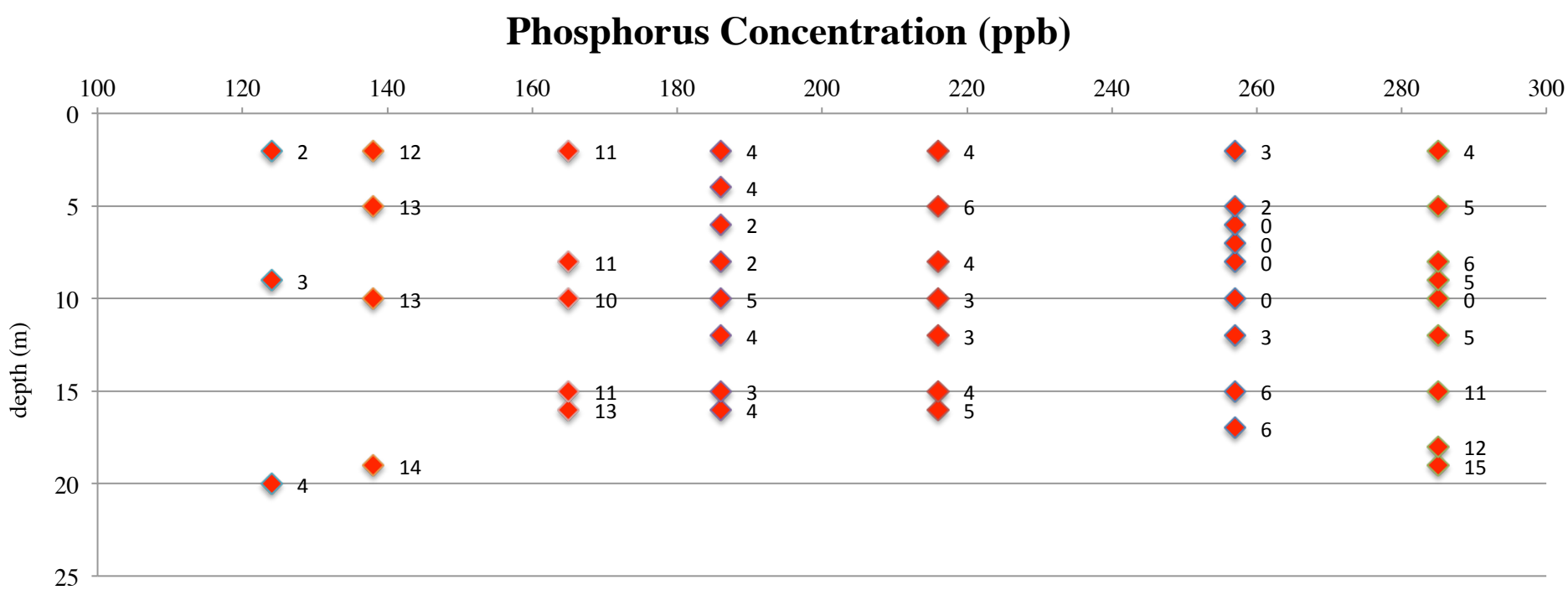
# Long Pond North Iron Concentration (ppb)



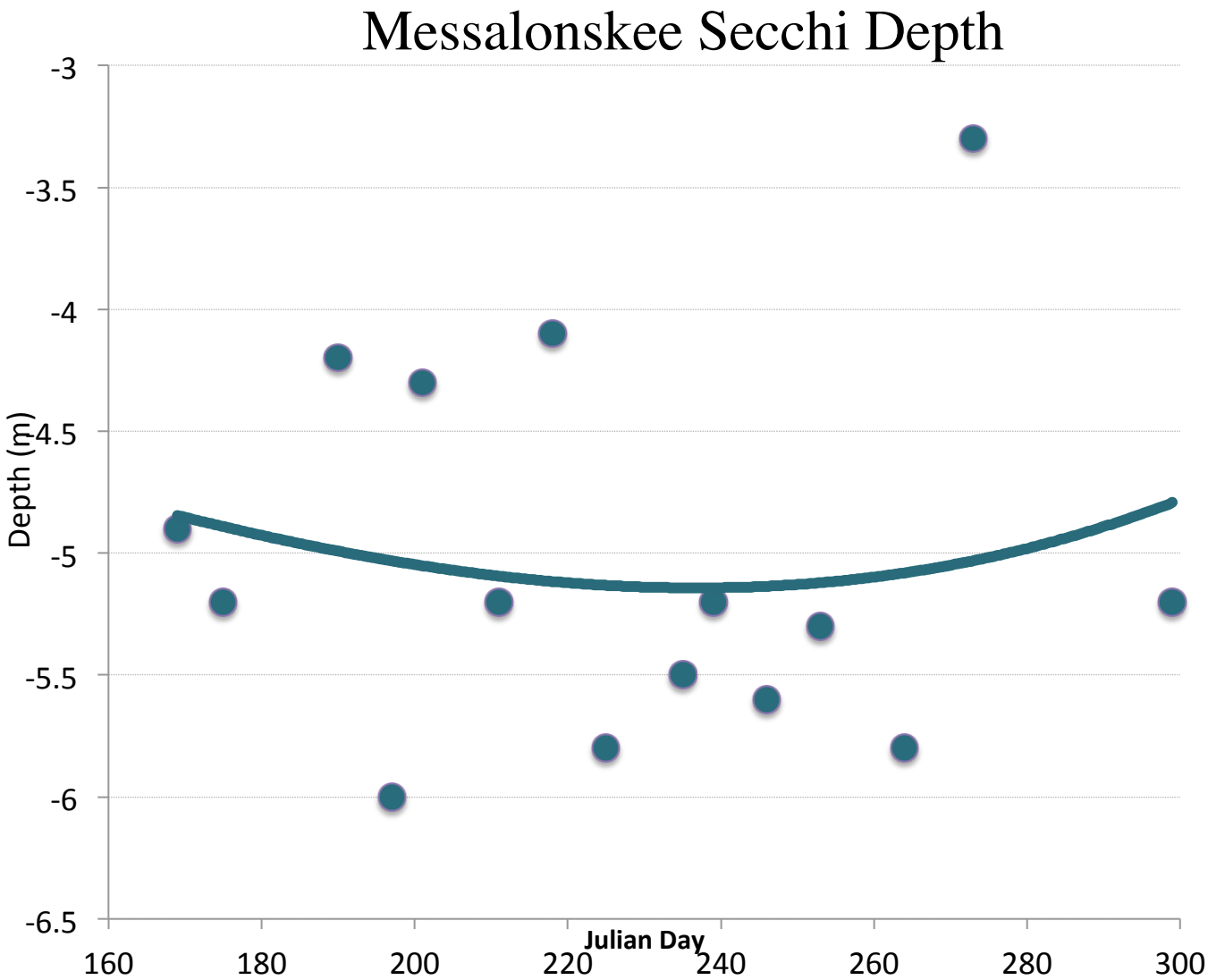

# Aluminum Concentration (ppb)




Long Pond North Secchi Depth
depth (m)
-4.5
-5
-5.5
-6
-6.5
-7
-7.5
-8
-8.5
100
120
140
160
180
200
220
240
260
280
300

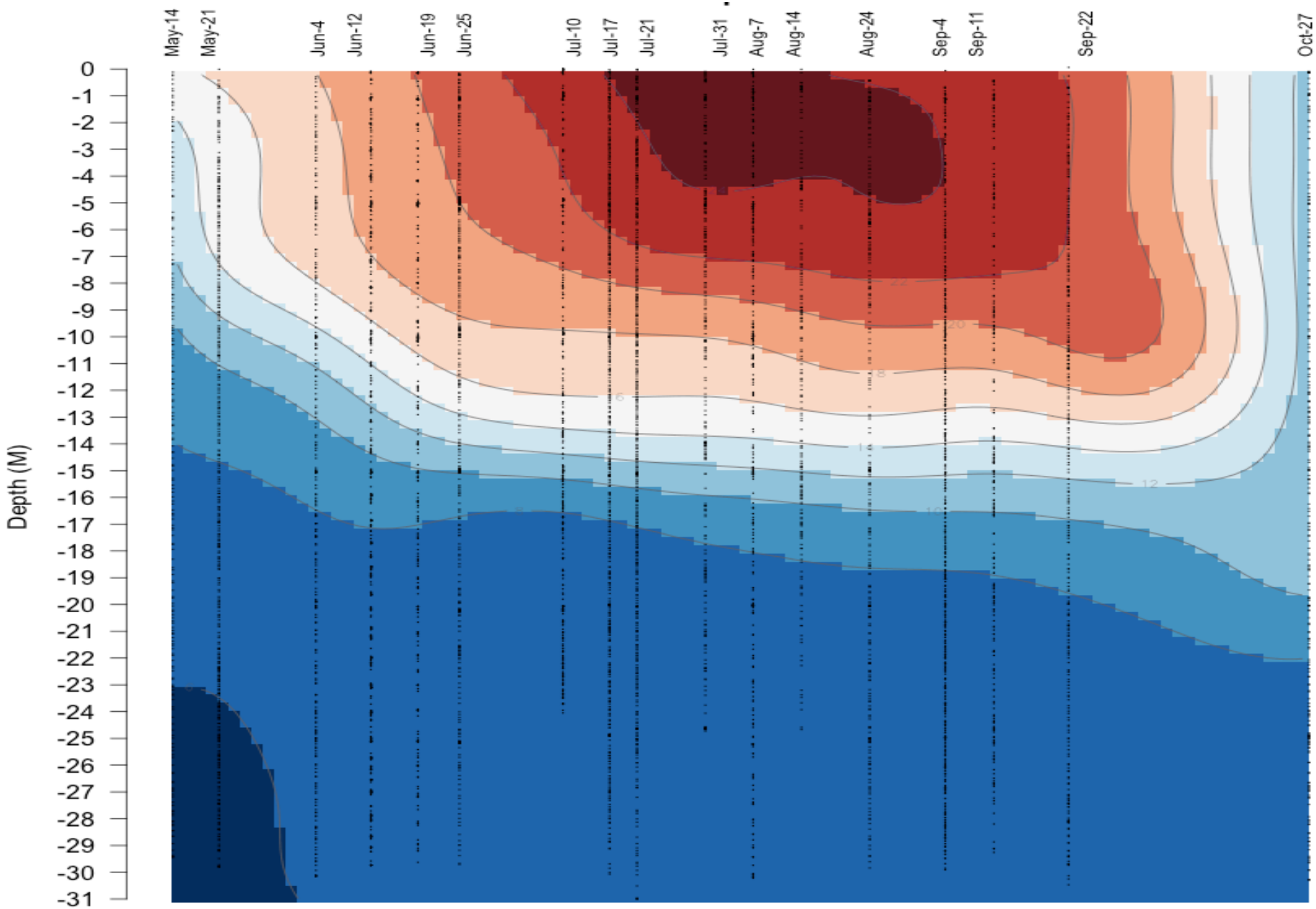

Phosphorus Concentration (ppb)
depth (m)
100
120
140
160
180
200
220
240
260
280
300
0
5
10
15
20
25
2
12
11
4
4
3
4
4
13
6
2
5
2
0
0
11
2
4
0
6
3
13
10
5
3
0
0
5
4
3
3
5
11
13
3
4
4
6
11
6
14
12
15
4

| Depth (M) | % Volume | % Surface Area |
|---|---|---|
| 1 | 11.5 | 11.1 |
| 2 | 10.9 | 10.7 |
| 3 | 10.3 | 10.0 |
| 4 | 9.7 | 9.5 |
| 5 | 8.8 | 8.8 |
| 6 | 8.0 | 7.9 |
| 7 | 7.3 | 7.2 |
| 8 | 6.5 | 6.6 |
| 9 | 5.3 | 5.7 |
| 10 | 4.1 | 4.4 |
| 11 | 3.3 | 3.5 |
| 12 | 2.6 | 2.9 |
| 13 | 1.9 | 2.1 |
| 14 | 1.4 | 1.5 |
| 15 | 1.1 | 1.2 |
| 16 | 1.0 | 1.0 |
| 17 | 0.8 | 0.8 |
| 18 | 0.7 | 0.7 |
| 19 | 0.6 | 0.6 |
| 20 | 0.6 | 0.6 |
| 21 | 0.5 | 0.5 |
| 22 | 0.4 | 0.4 |
| 23 | 0.4 | 0.4 |
| 24 | 0.4 | 0.4 |
| 25 | 0.3 | 0.3 |
| 26 | 0.3 | 0.3 |
| 27 | 0.3 | 0.3 |
| 28 | 0.2 | 0.2 |
| 29 | 0.2 | 0.2 |
| 30 | 0.2 | 0.2 |
| 31 | 0.1 | 0.1 |
| 32 | 0.1 | 0.1 |
| 33 | 0.0 | 0.0 |

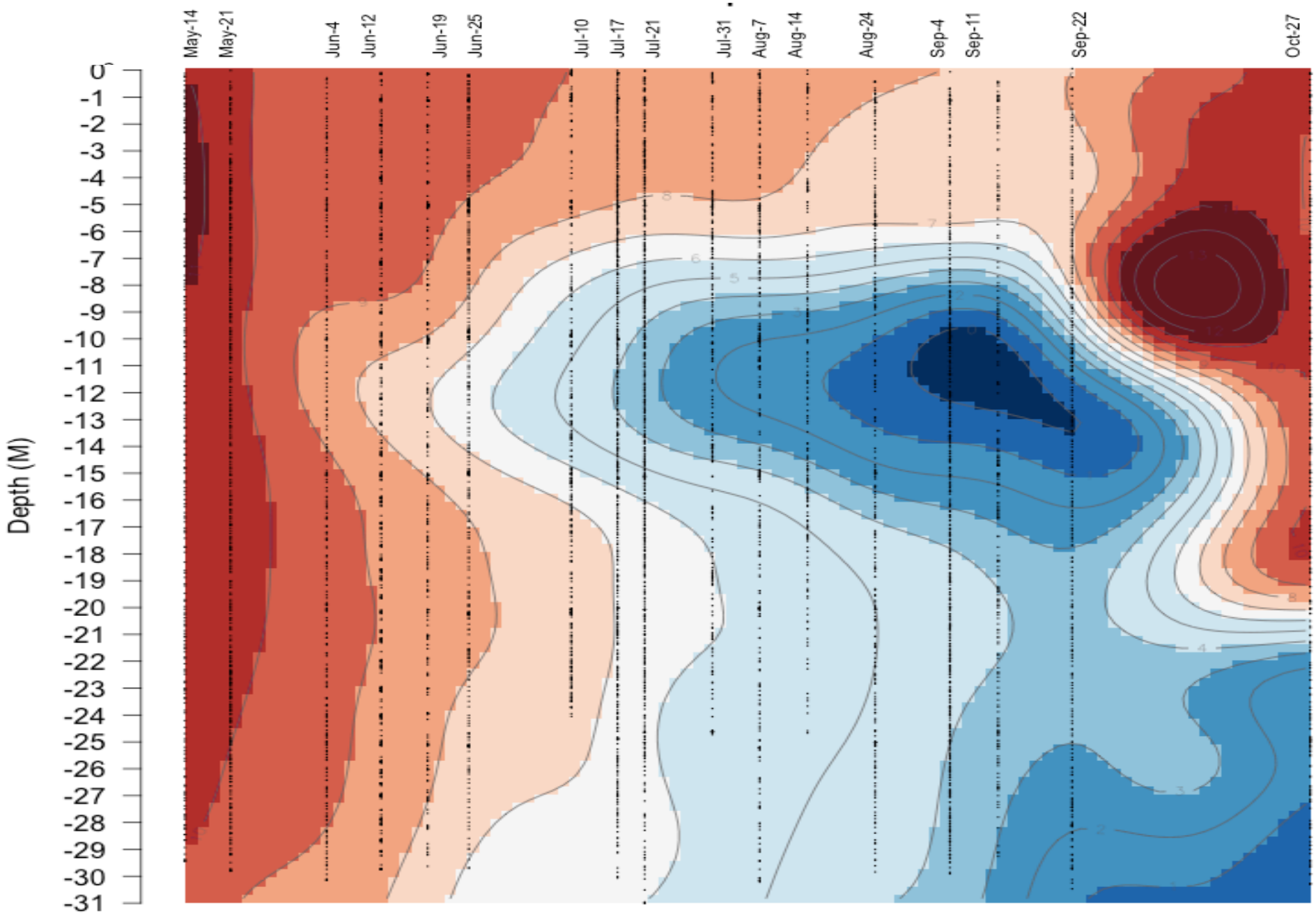



| | | | |
|---|---|---|---|
| Area ($km^2$) | 14.94 | $O_2$ Loss Rate (metric tons/day) | 0.60 |
| Volume (millions $m^3$) | 136 | Flushing Rate (#/year) | 1.59 |
| Mean Depth (m) | 10.06 | | |
| Morphometric Ratio | 2.6 | Days Sampled | 23 |
| Thermocline Depth (m) | 7 | Number of Samples | 6,911 |
| Anoxic Factor (lake area * days) | 3.17 | Secchi Mean (M) | 5.4 |

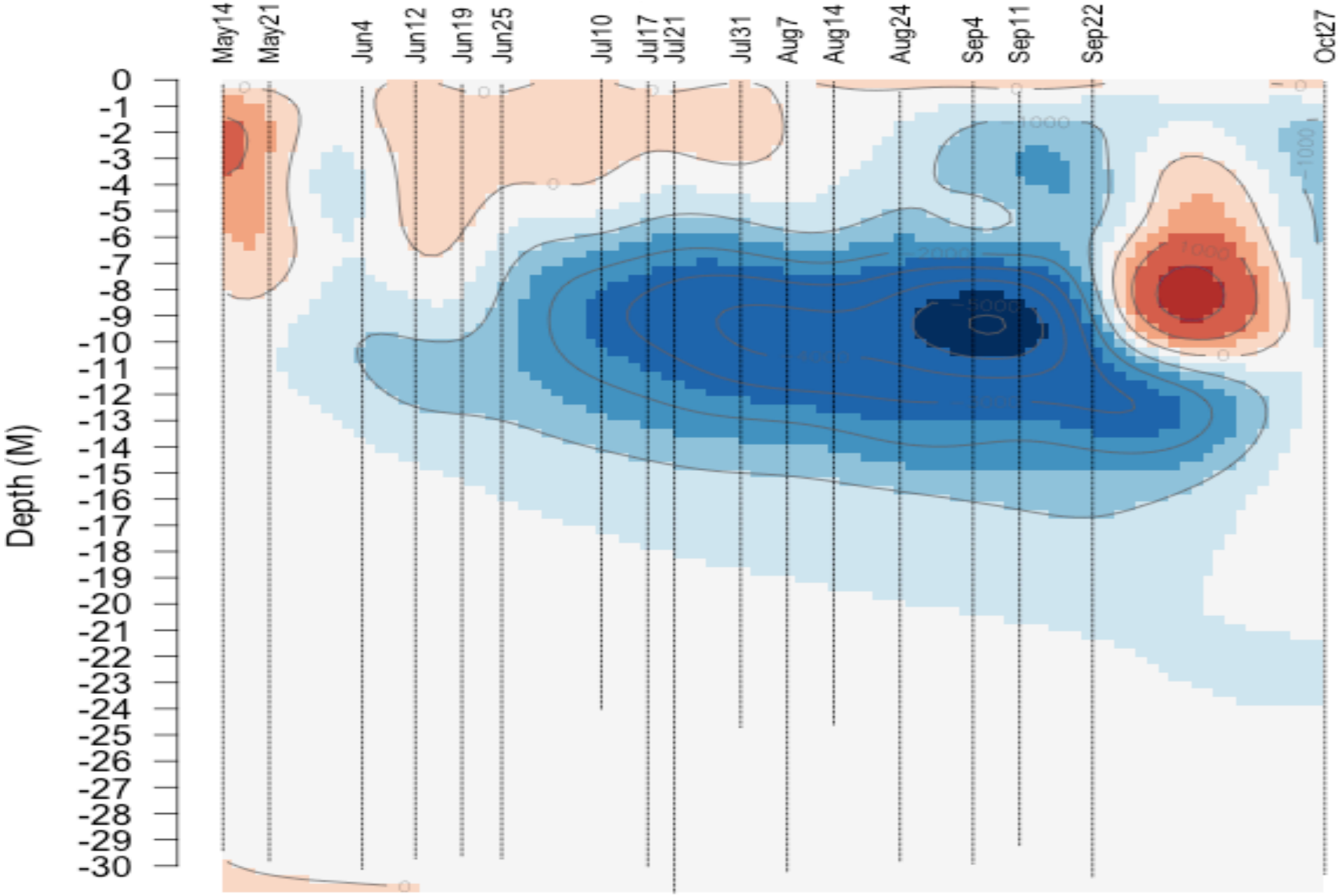
# Messalonskee Lake Temperature (ºC)

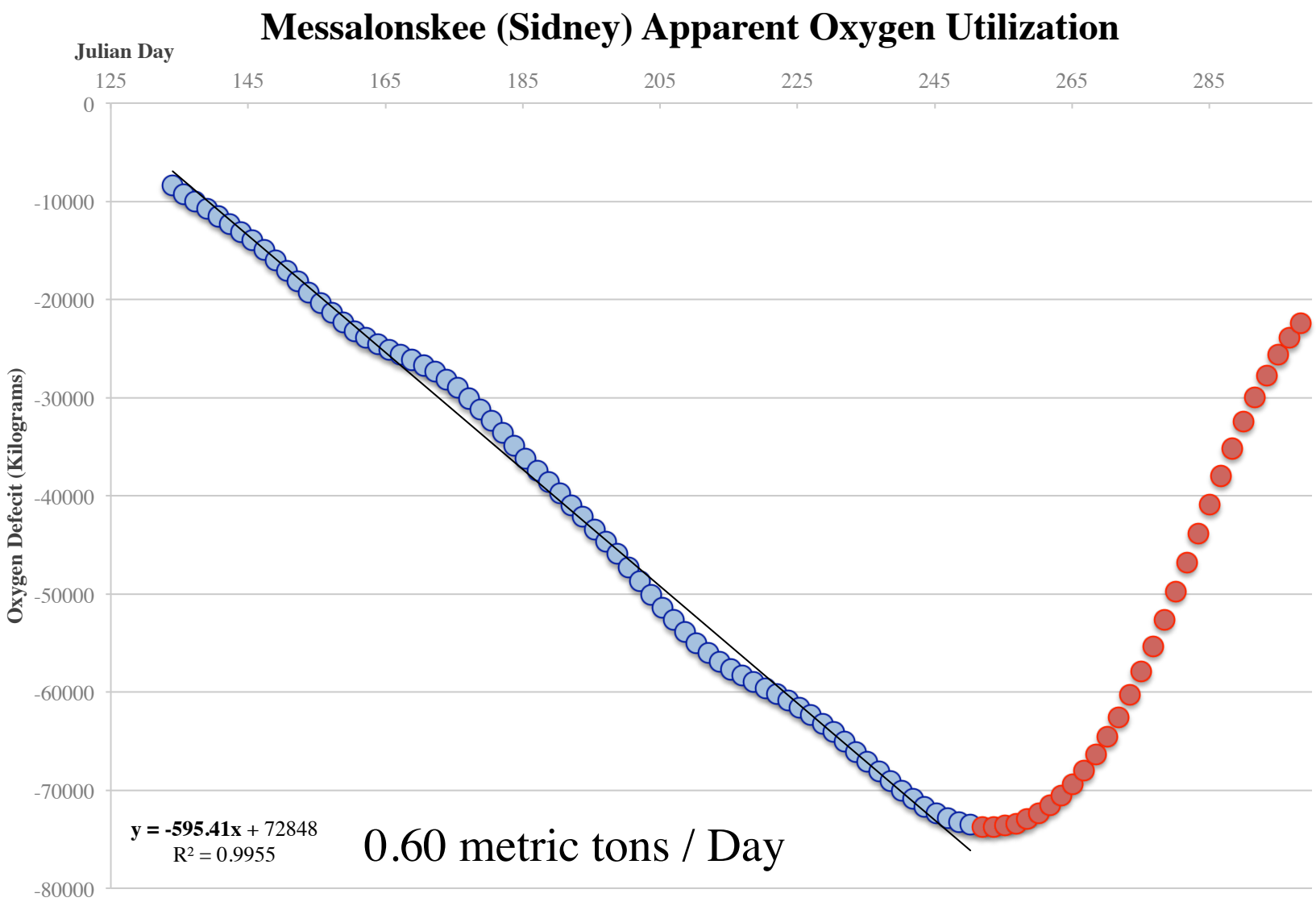


# Messalonskee Lake Oxygen Saturation (ppm)

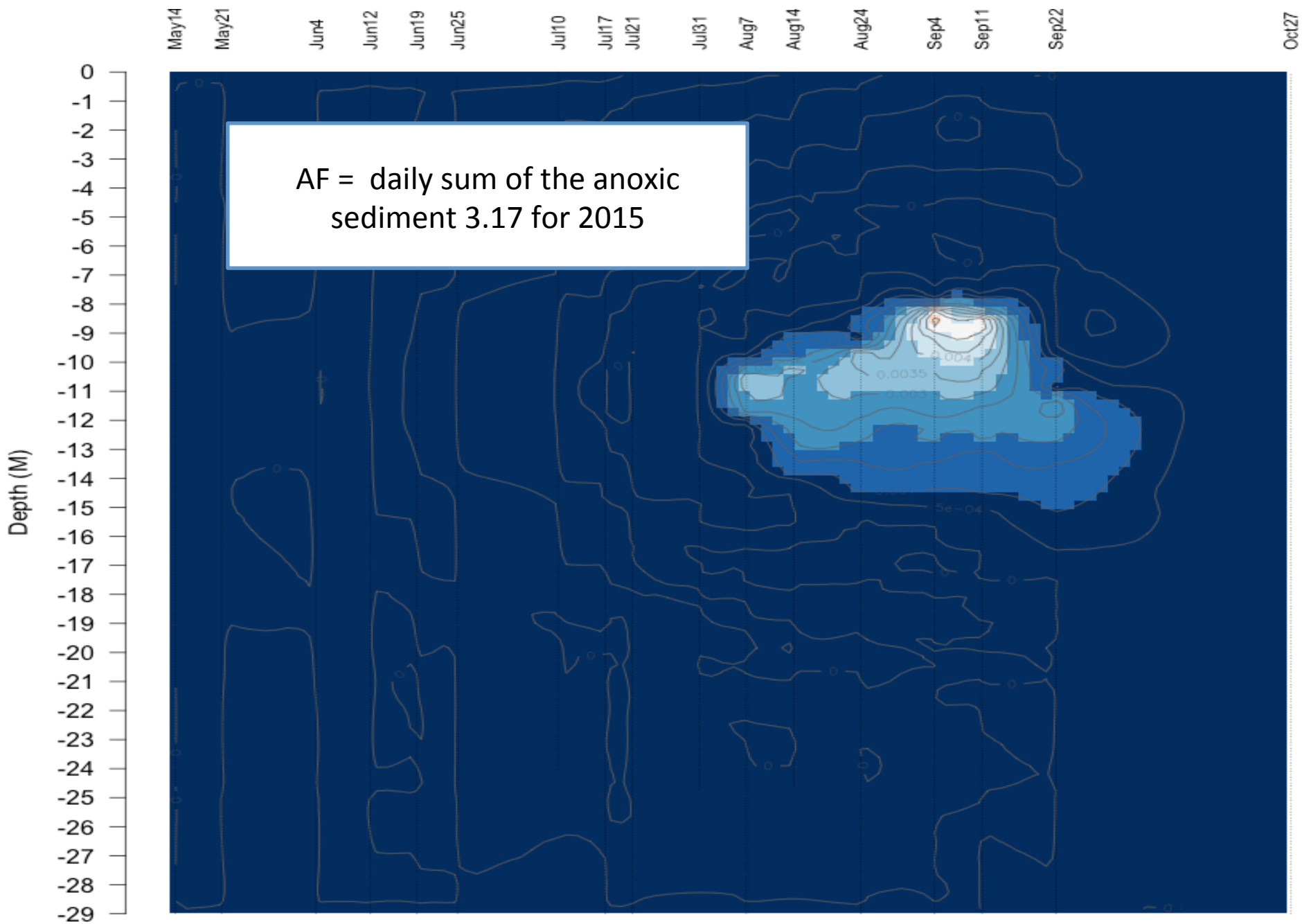


Messalonskee Lake Oxygen Anomaly (kg)

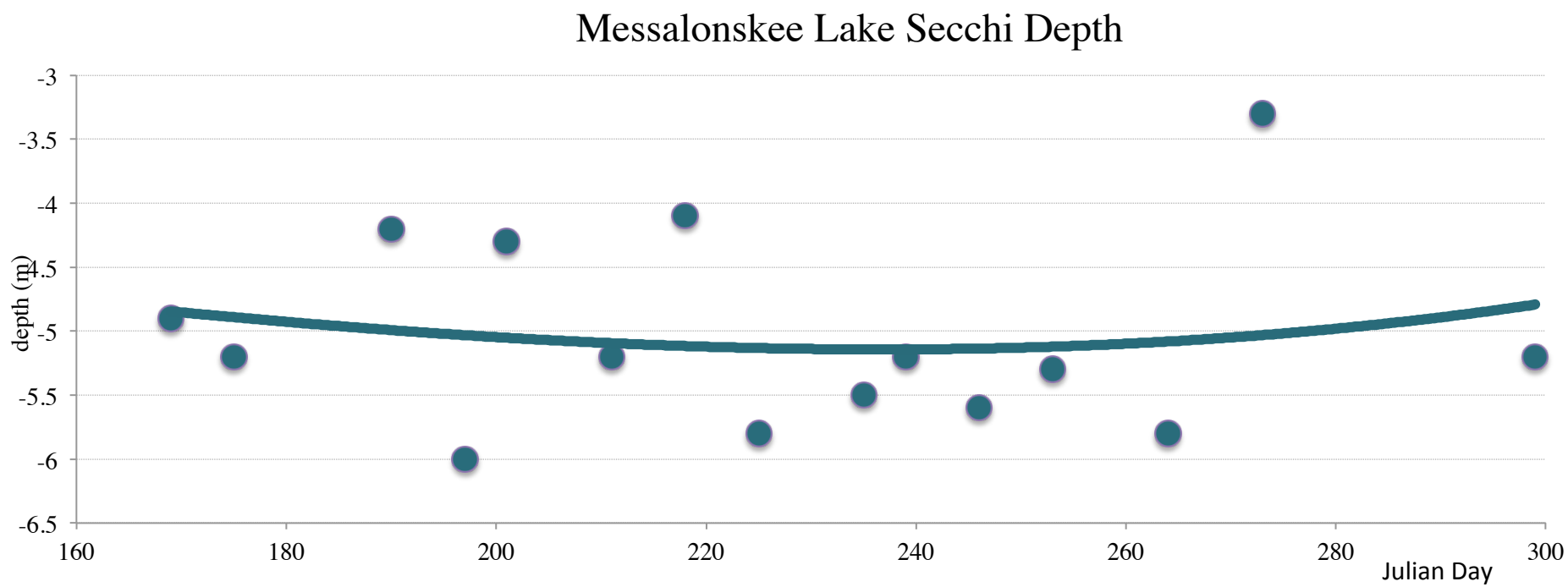


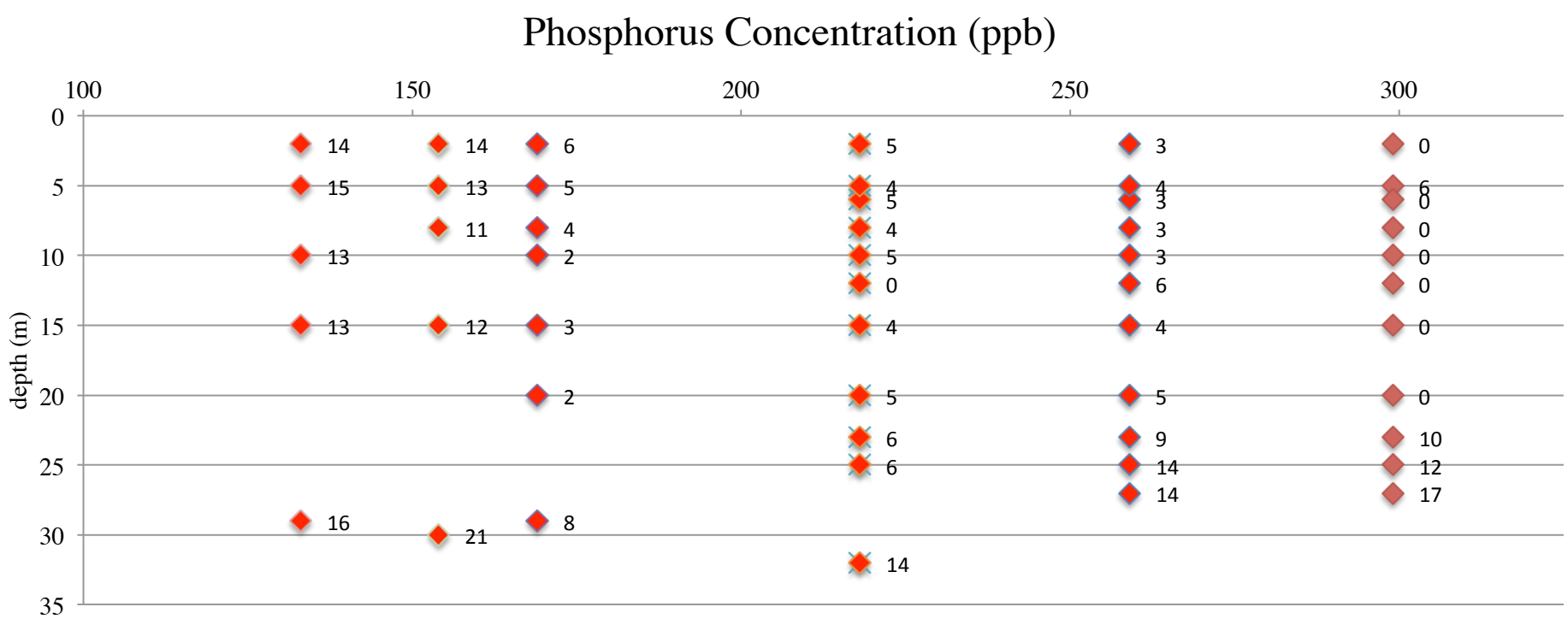

Messalonskee (Sidney) Apparent Oxygen Utilization
Julian Day
125
145
165
185
205
225
245
265
285
0
-10000
-20000
-30000
-40000
-50000
-60000
-70000
-80000
Oxygen Defecit (Kilograms)
y = -595.41x + 72848
R² = 0.9955
0.60 metric tons / Day

# Messalonskee Lake Anoxic Sediment (Fraction of Lake Area)



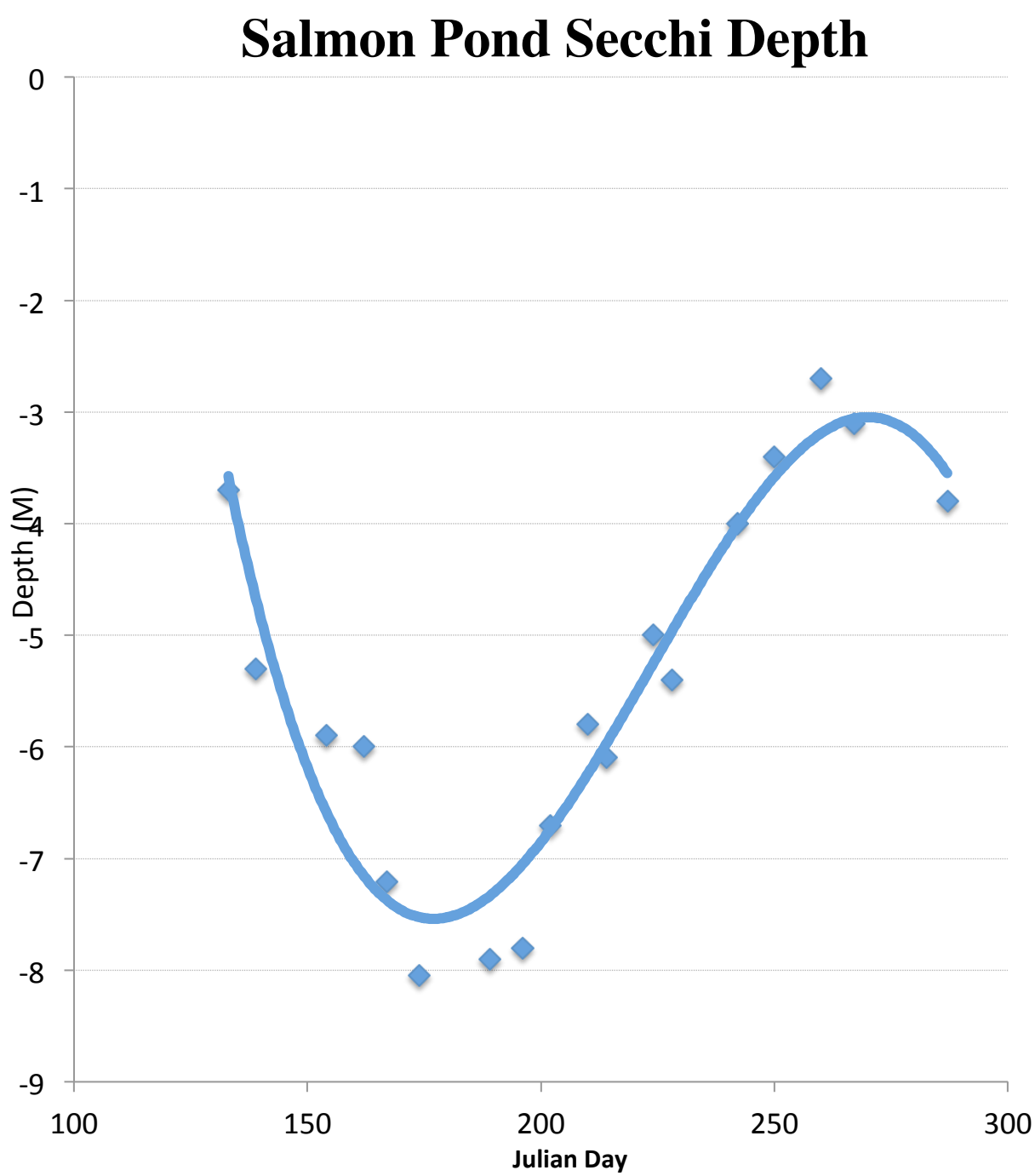

AF = daily sum of the anoxic sediment 3.17 for 2015


Messalonskee Lake Secchi Depth
depth (m)
-3
-3.5
-4
-4.5
-5
-5.5
-6
-6.5
160
180
200
220
240
260
280
300
Julian Day

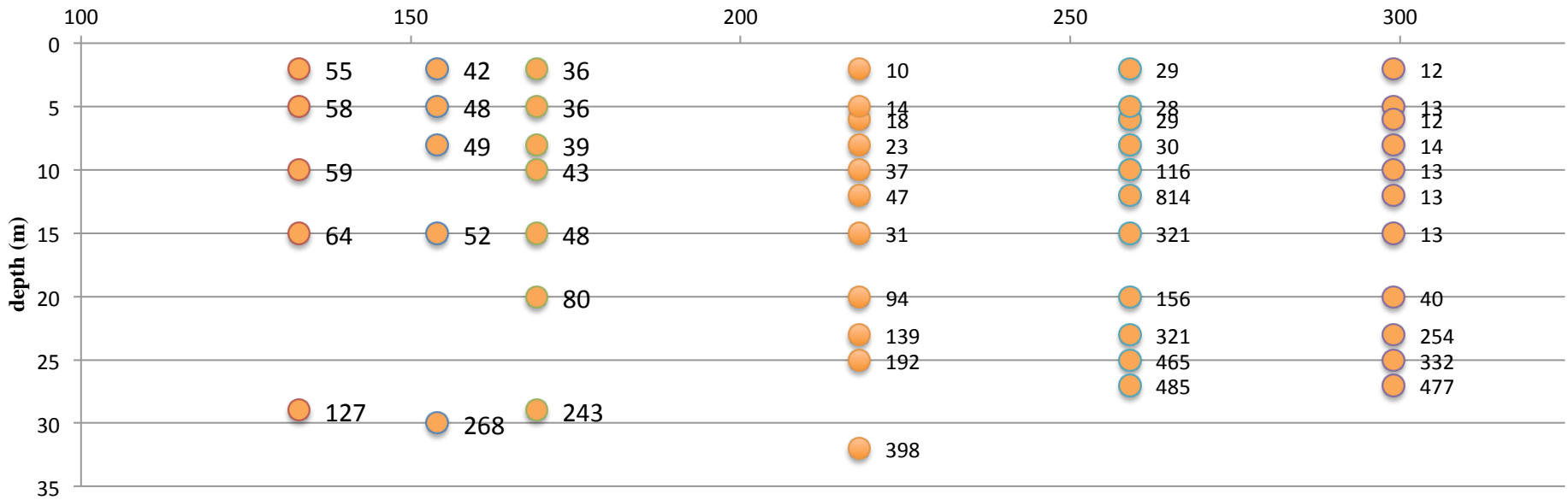

Phosphorus Concentration (ppb)
depth (m)
100
150
200
250
300
0
5
10
15
20
25
30
35
14
15
13
13
16
14
13
11
12
21
6
5
4
2
3
2
8
5
4
5
4
5
0
4
5
6
6
14
3
4
3
3
3
6
4
5
9
14
14
0
6
0
0
0
0
0
0
10
12
17

| Depth (M) | % Volume | % Area |
|---|---|---|
| 0 | 12.39 | 11.65 |
| 1 | 12.35 | 11.65 |
| 2 | 11.90 | 11.57 |
| 3 | 10.94 | 10.80 |
| 4 | 9.73 | 9.79 |
| 5 | 8.60 | 8.53 |
| 6 | 7.74 | 7.65 |
| 7 | 6.99 | 6.92 |
| 8 | 6.16 | 6.24 |
| 9 | 5.02 | 5.35 |
| 10 | 3.60 | 4.12 |
| 11 | 2.34 | 2.70 |
| 12 | 1.34 | 1.74 |
| 13 | 0.58 | 0.84 |
| 14 | 0.22 | 0.30 |
| 15 | 0.08 | 0.12 |
| 16 | 0.02 | 0.03 |
| 17 | 0.00 | 0.01 |
| 18 | 0.00 | 0.00 |

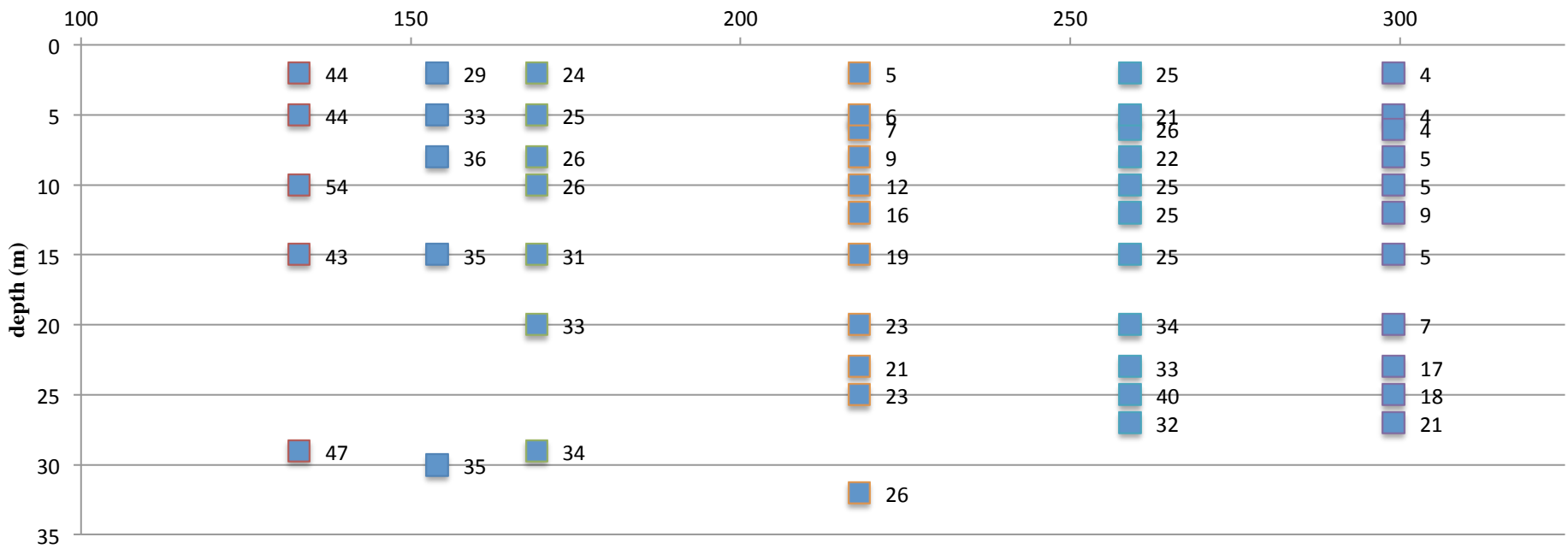
| | |
|---|---|
| Area ($km^2$) | 2.81 |
| Volume (millions $m^3$) | 2.00 |
| Mean Depth (m) | 7.01 |
| Morphometric Ratio | 4.18 |
| Thermocline Depth (m) | 6.5 |
| Anoxic Factor (lake area * days) | 14.93 |
| $O_2$ Loss Rate (metric tons/day) | 0.30 |
| Flushing Rate (#/year) | 0.54 |
| | |
| Days Sampled | 18 |
| Number of Samples | 2,661 |
| Secchi Mean (M) | 5.4 |

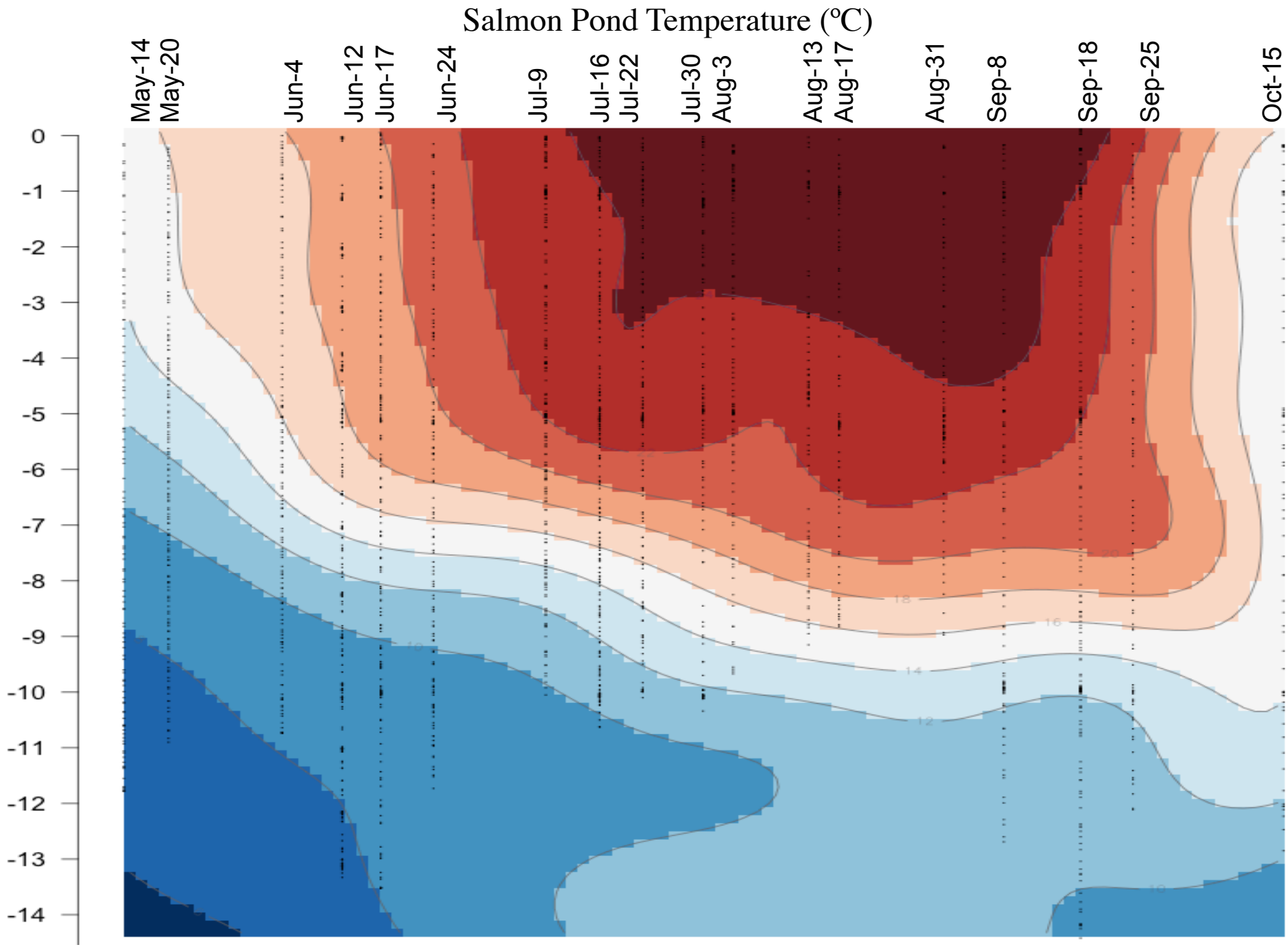


# Messalonskee Lake Iron Concentration (ppb)

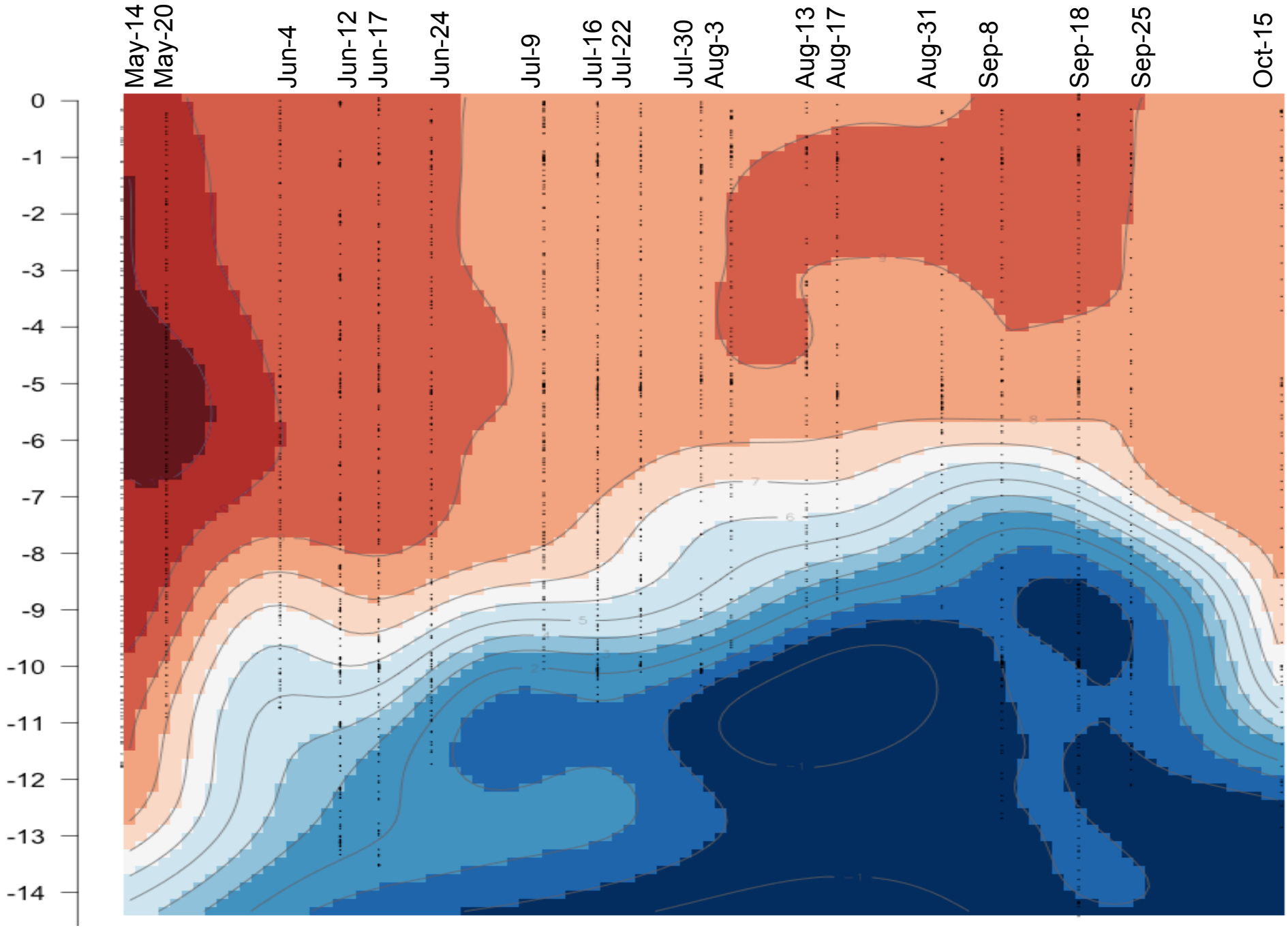



# Aluminum Concentration (ppb)

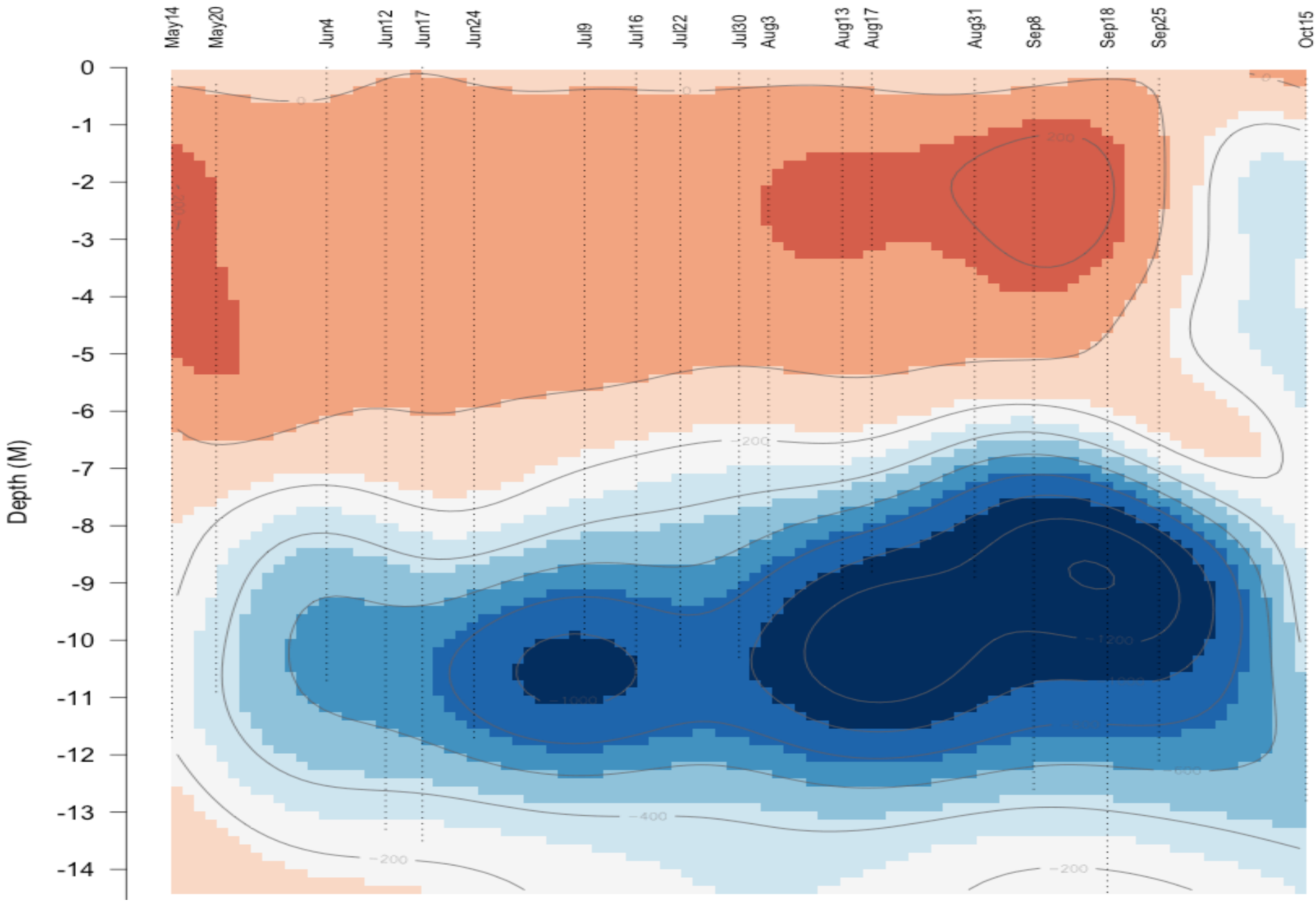


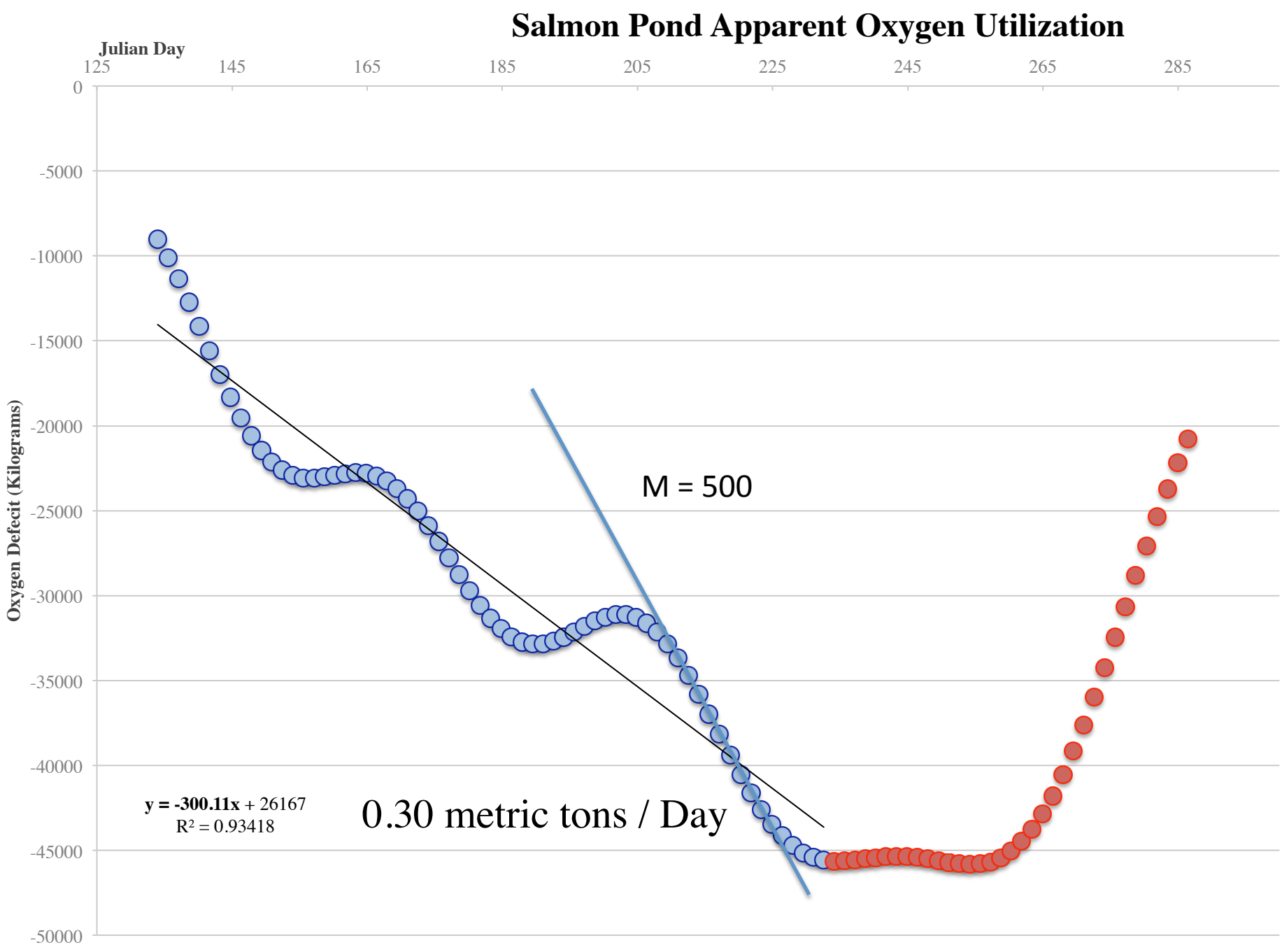

Salmon Pond Temperature (ºC)
May-14
May-20
Jun-4
Jun-12
Jun-17
Jun-24
Jul-9
Jul-16
Jul-22
Jul-30
Aug-3
Aug-13
Aug-17
Aug-31
Sep-8
Sep-18
Sep-25
Oct-15
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14

# Salmon Pond Oxygen Saturation (ppm)

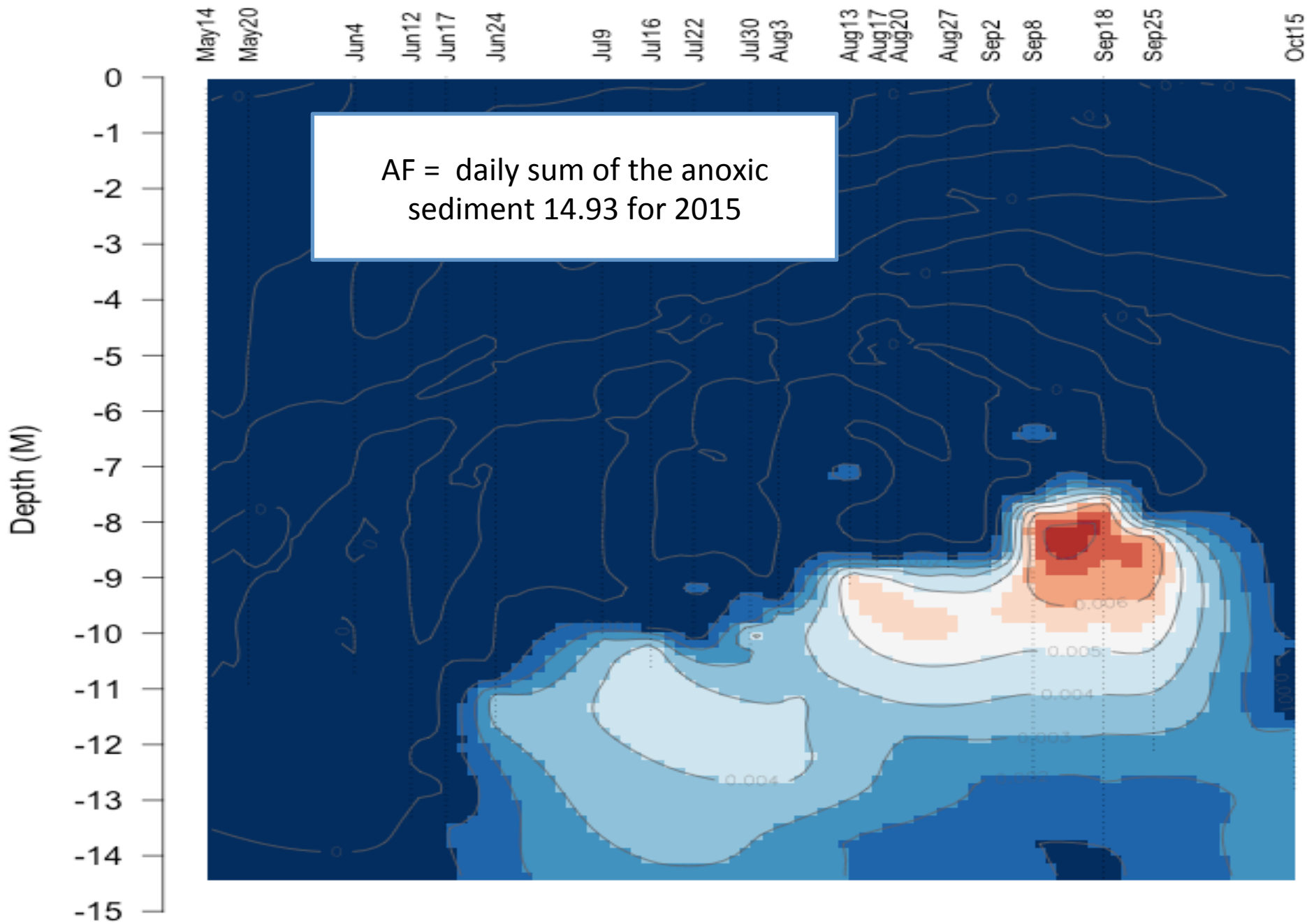


# Salmon Pond Oxygen Anomaly (kg)

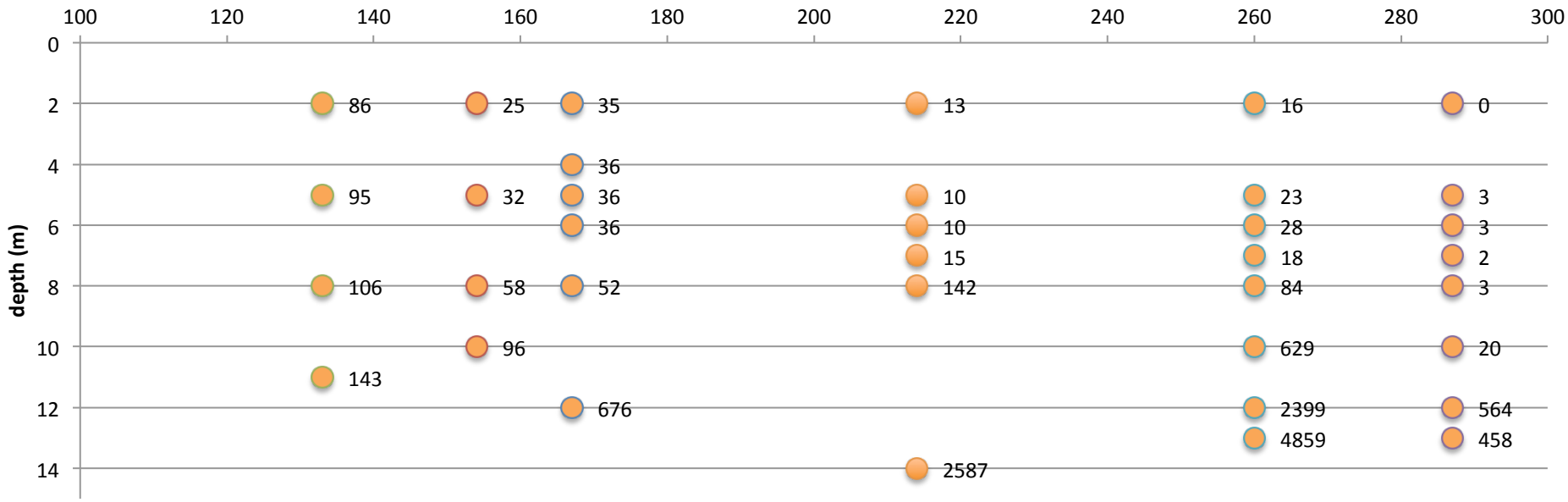



Salmon Pond Apparent Oxygen Utilization
Julian Day
125
145
165
185
205
225
245
265
285
0
-5000
-10000
-15000
-20000
-25000
-30000
-35000
-40000
-45000
-50000
Oxygen Defecit (Kilograms)
M = 500
y = -300.11x + 26167
R² = 0.93418
0.30 metric tons / Day

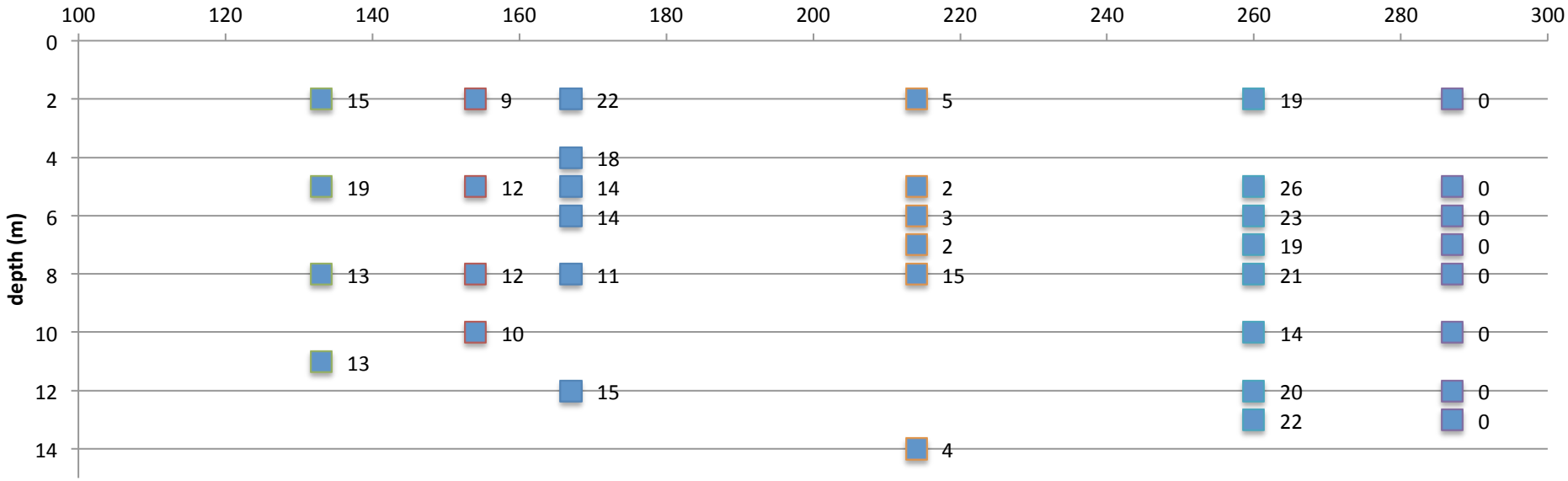
# Salmon Pond Anoxic Sediment (Fraction of Lake Area)

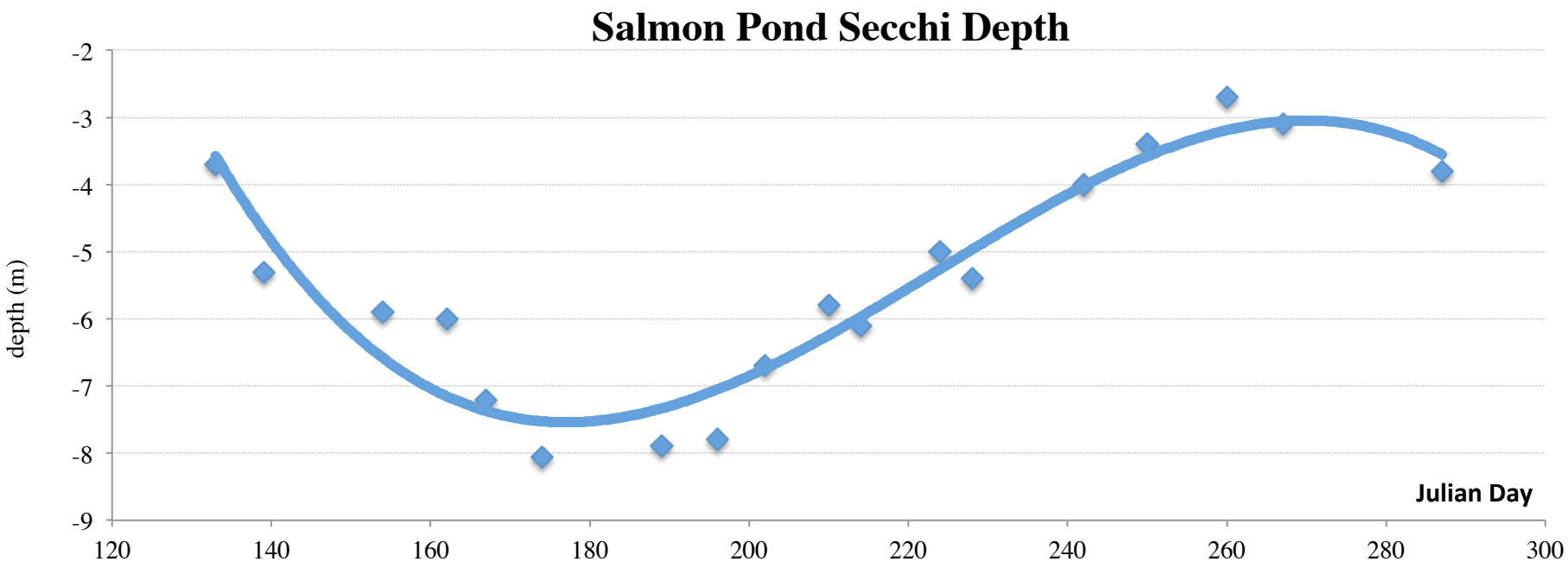


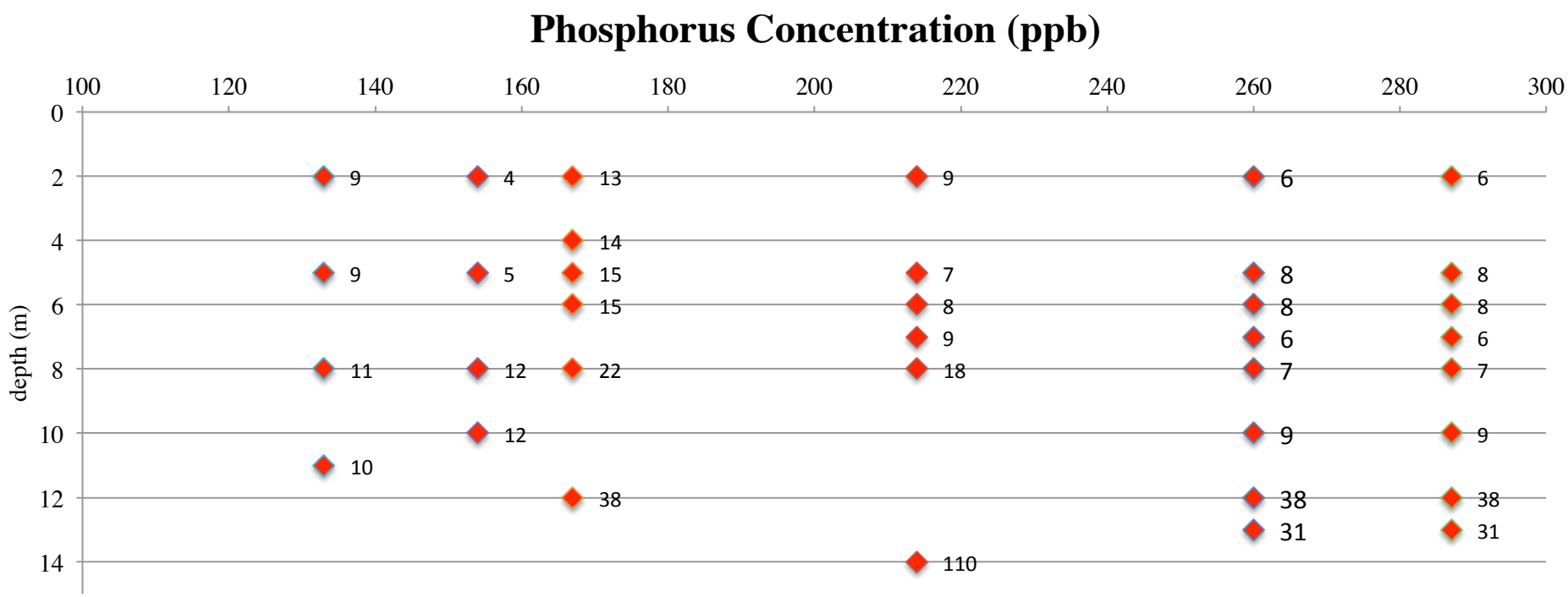
# Salmon Pond Iron Concentration (ppb)




# Aluminum Concentration (ppb)

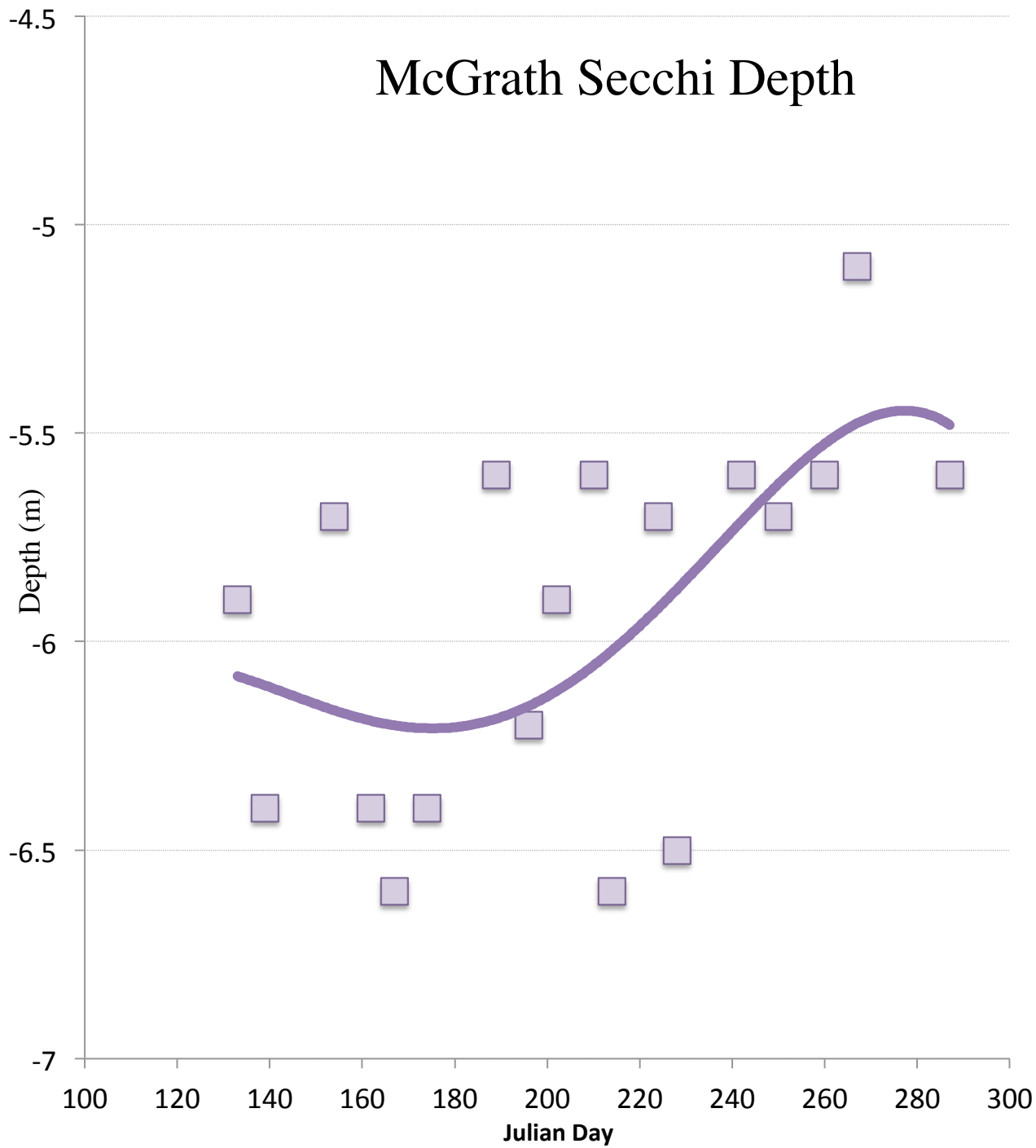



Salmon Pond Secchi Depth
depth (m)
-2
-3
-4
-5
-6
-7
-8
-9
120
140
160
180
200
220
240
260
280
300
Julian Day

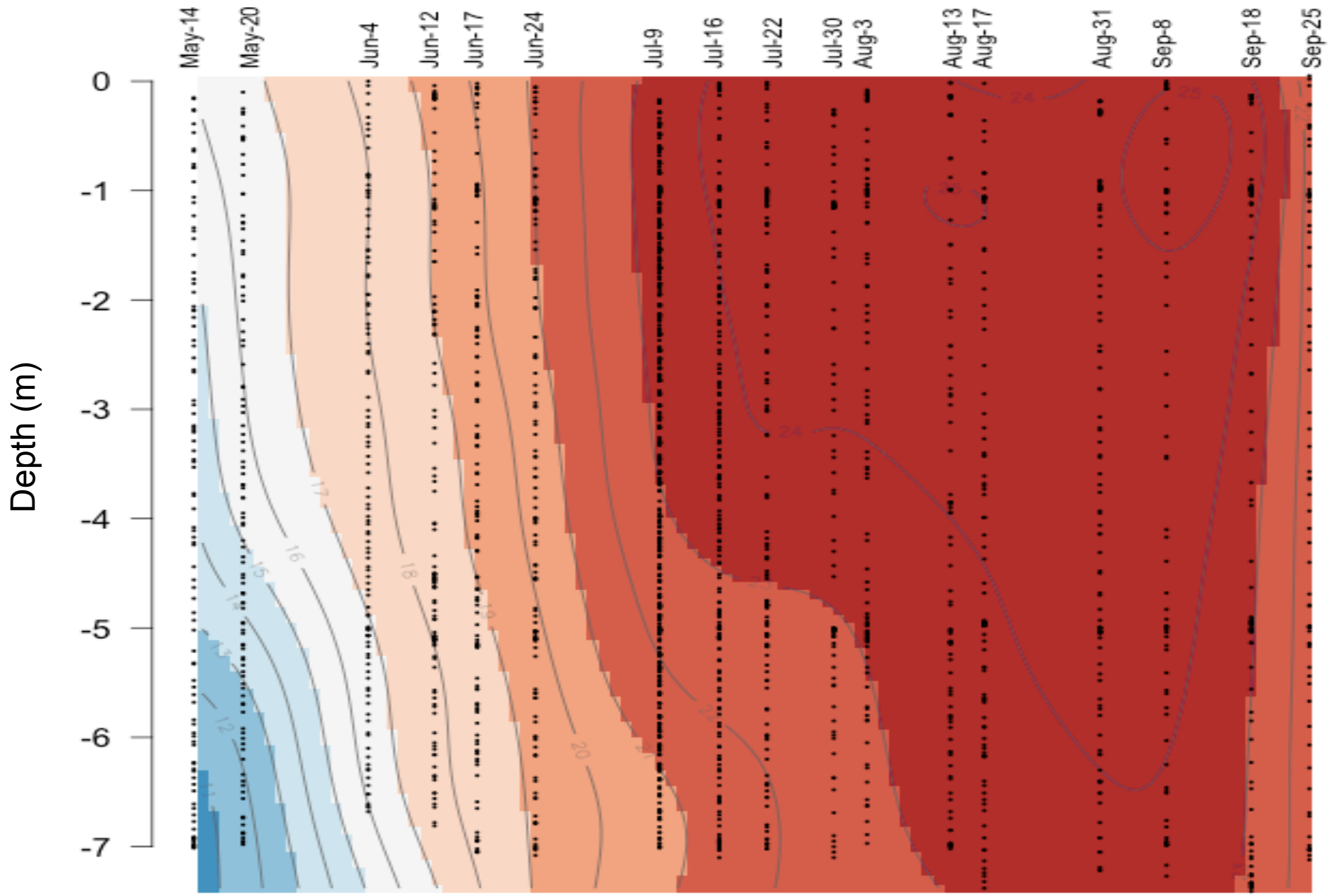

Phosphorus Concentration (ppb)
depth (m)
100
120
140
160
180
200
220
240
260
280
300
0
2
4
6
8
10
12
14
9
4
13
9
6
6
14
9
5
15
7
8
8
15
8
8
8
9
6
6
11
12
22
18
7
7
12
9
9
10
38
38
38
31
31
110

| Depth (M) | % Volume | % Surface Area |
|---|---|---|
| 0 | 15.08 | 13.96 |
| 1 | 15.03 | 13.96 |
| 2 | 14.38 | 13.86 |
| 3 | 12.94 | 12.77 |
| 4 | 11.39 | 11.21 |
| 5 | 9.93 | 9.89 |
| 6 | 8.50 | 8.52 |
| 7 | 7.12 | 7.24 |
| 8 | 4.40 | 5.98 |
| 9 | 1.08 | 2.43 |
| 10 | 0.07 | 0.09 |
| 11 | 0.04 | 0.04 |
| 12 | 0.02 | 0.03 |
| 13 | 0.01 | 0.01 |
| 14 | 0.01 | 0.01 |
| 15 | 0.00 | 0.00 |
| 16 | 0.00 | 0.00 |
| 17 | 0.00 | 0.00 |
| 18 | 0.00 | 0.00 |

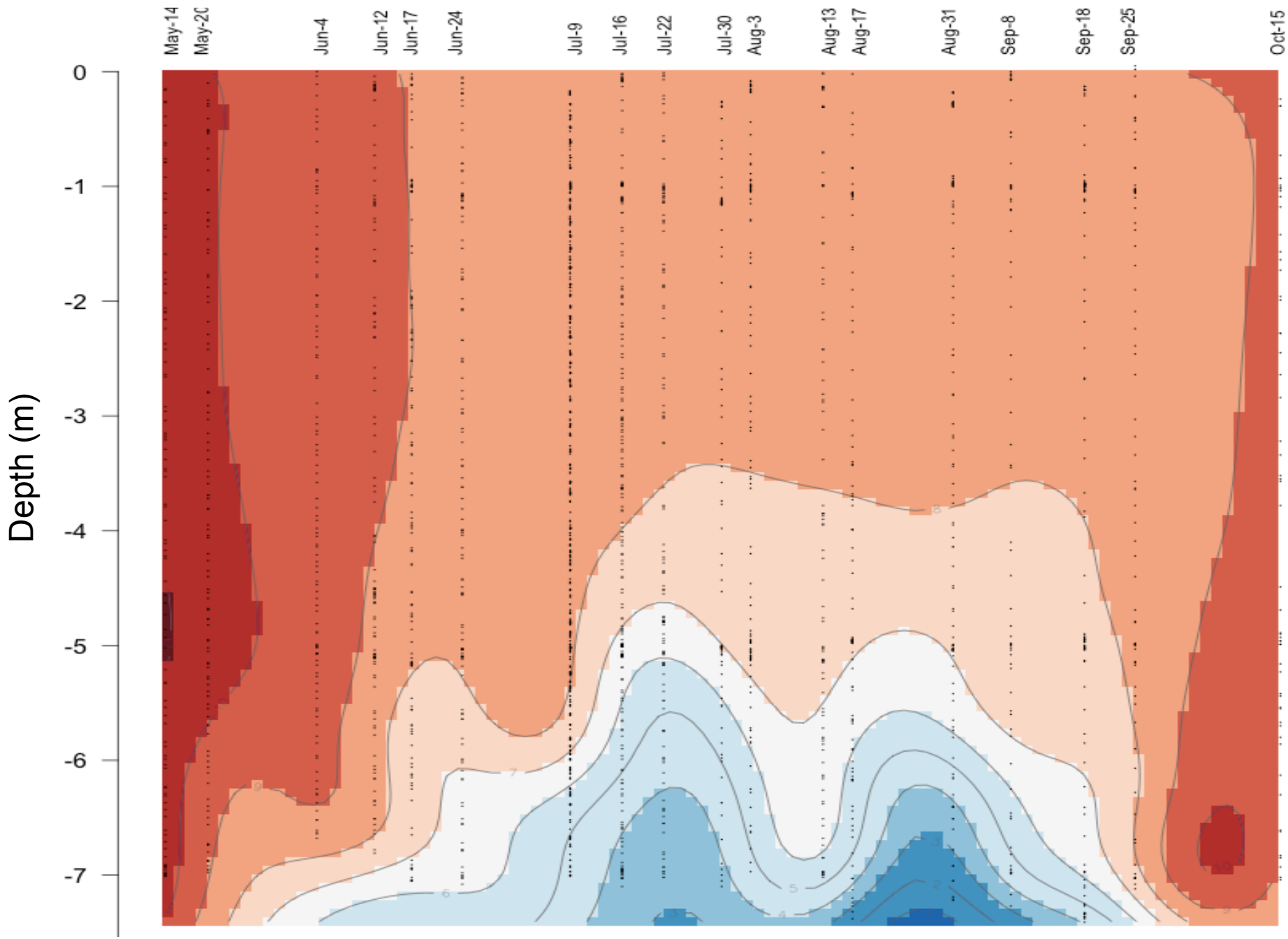
| | |
|---|---|
| Area ($km^2$) | 1.79 |
| Volume (millions $m^3$) | 18.4 |
| Mean Depth (m) | 6.62 |
| Morphometric Ratio | 3.55 |
| Thermocline Depth (m) | None |
| Anoxic Factor (lake area * days) | 0.61 |
| $O_2$ Loss Rate (metric tons/day) | 0.29 |
| Flushing Rate (#/year) | 0.69 |
| | |
| Days Sampled | 18 |
| Number of Samples | 2,408 |
| Secchi Mean (M) | 6 |



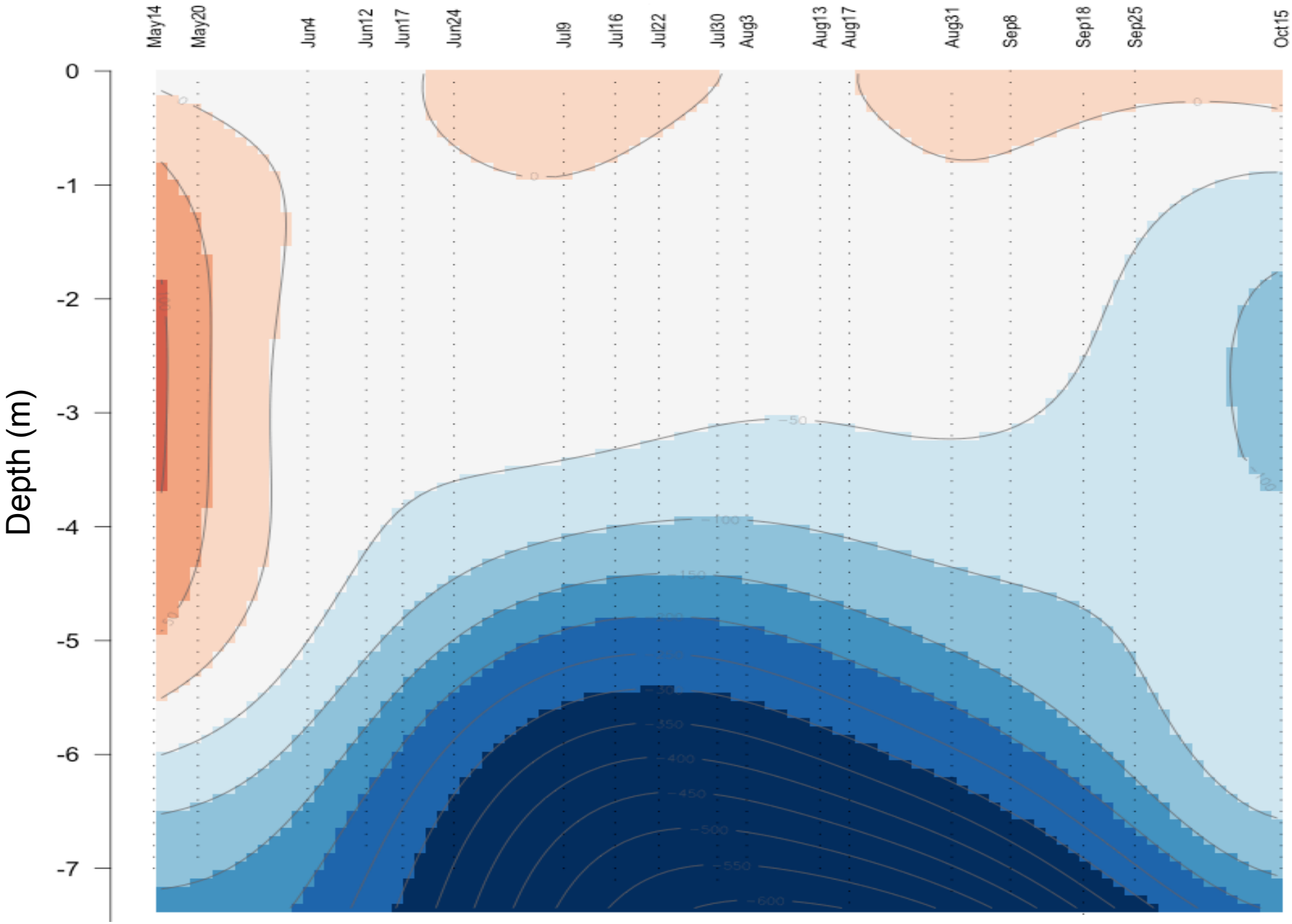
# McGrath Pond Temperature (ºC)

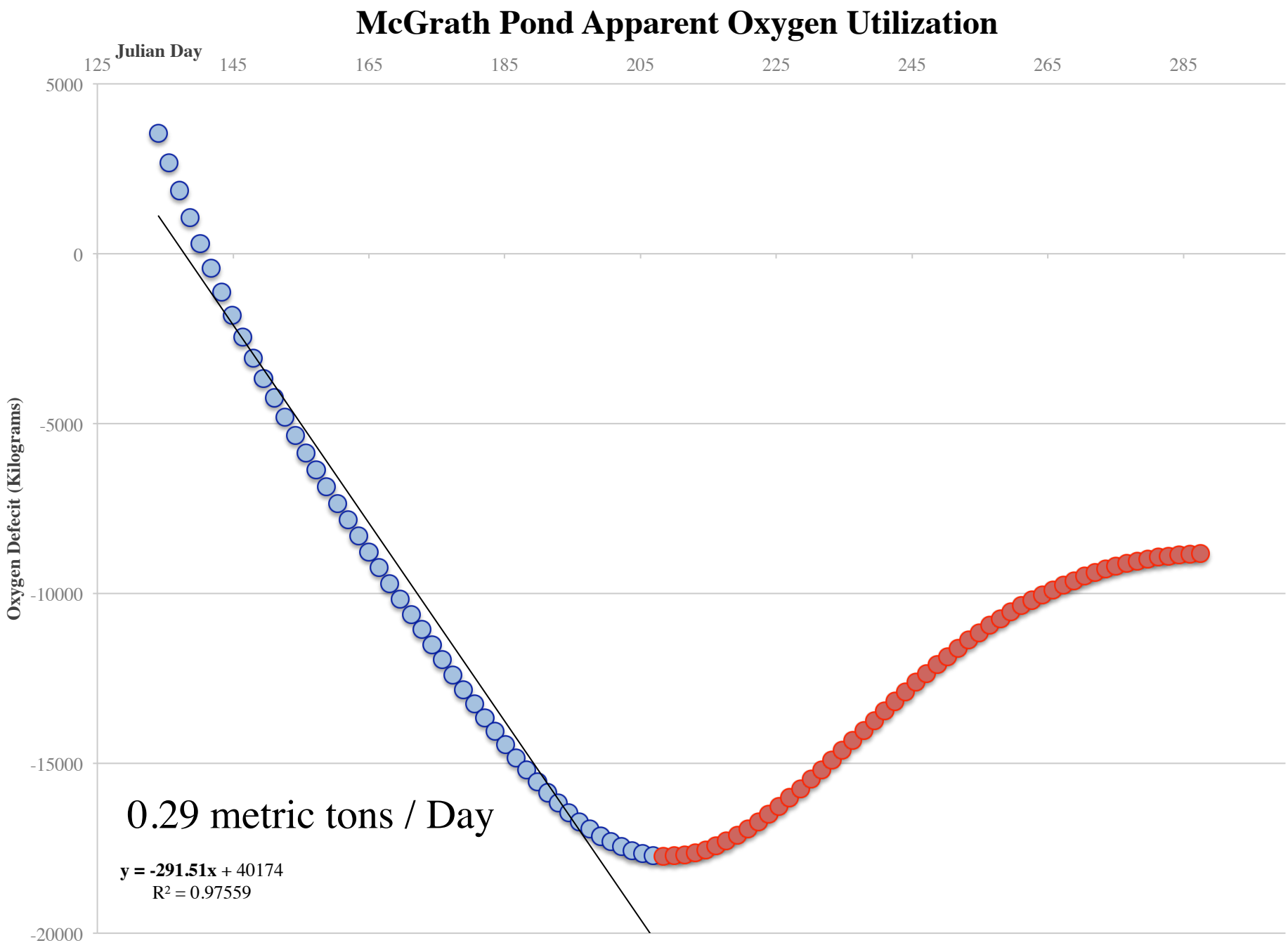


# McGrath Pond Oxygen Saturation (ppm)

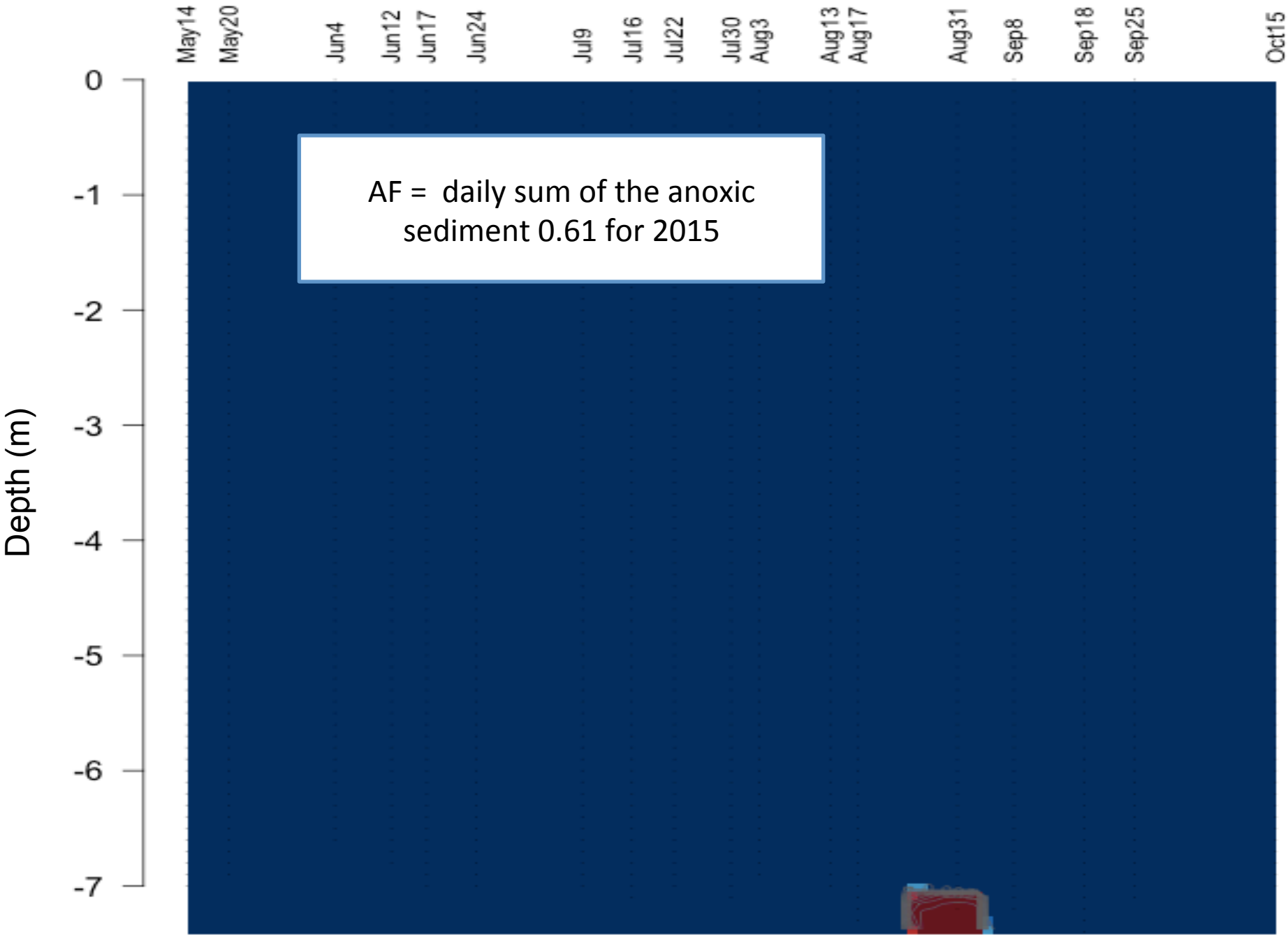


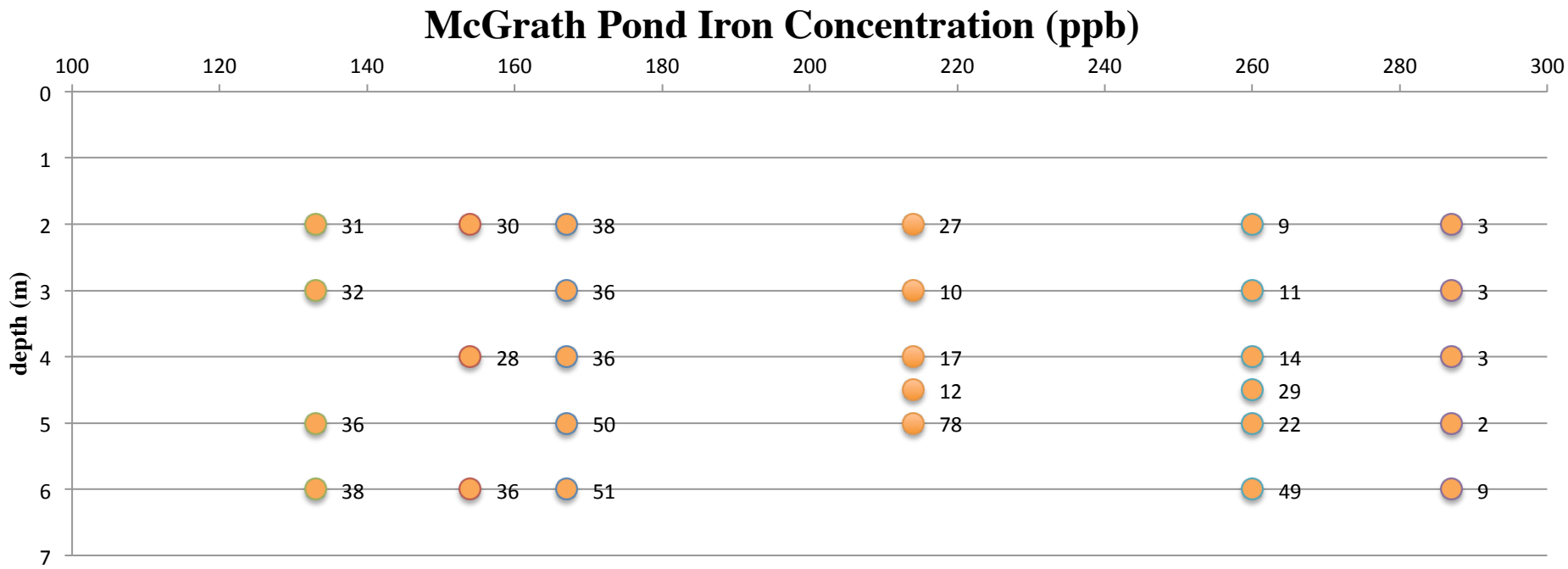
# McGrath Pond Oxygen Anomaly (kg)

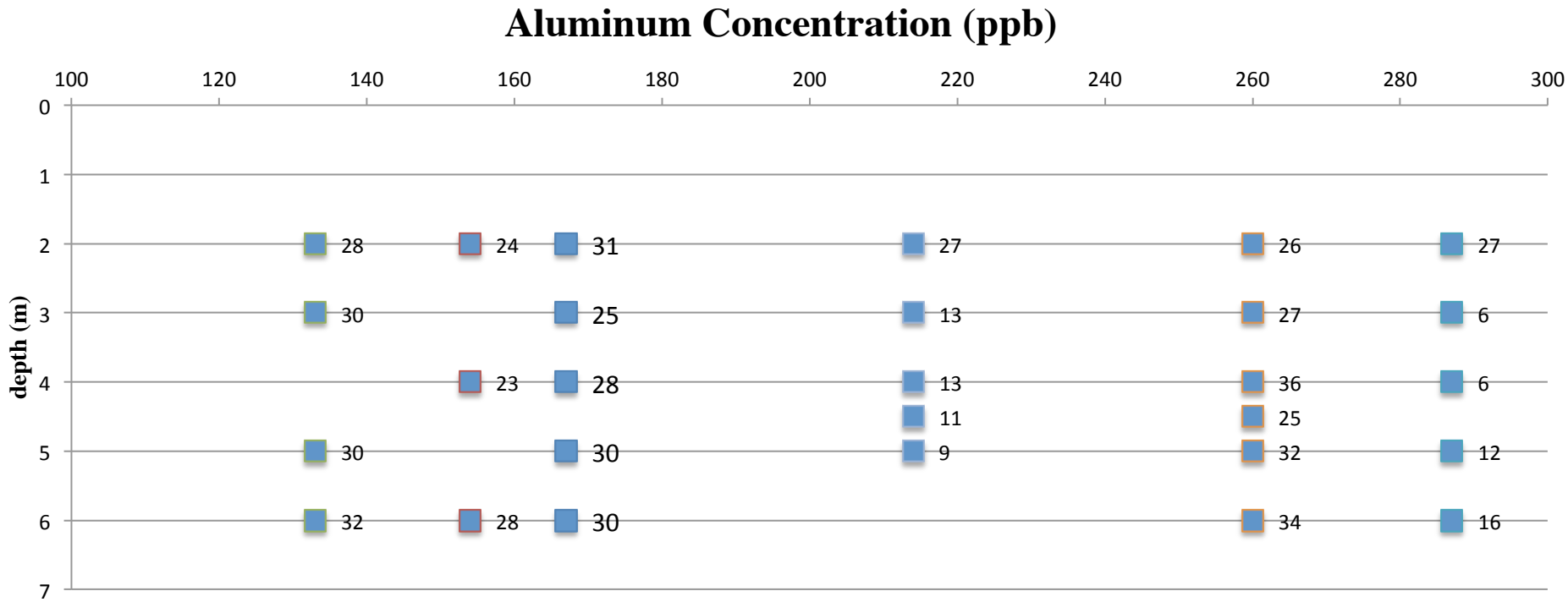


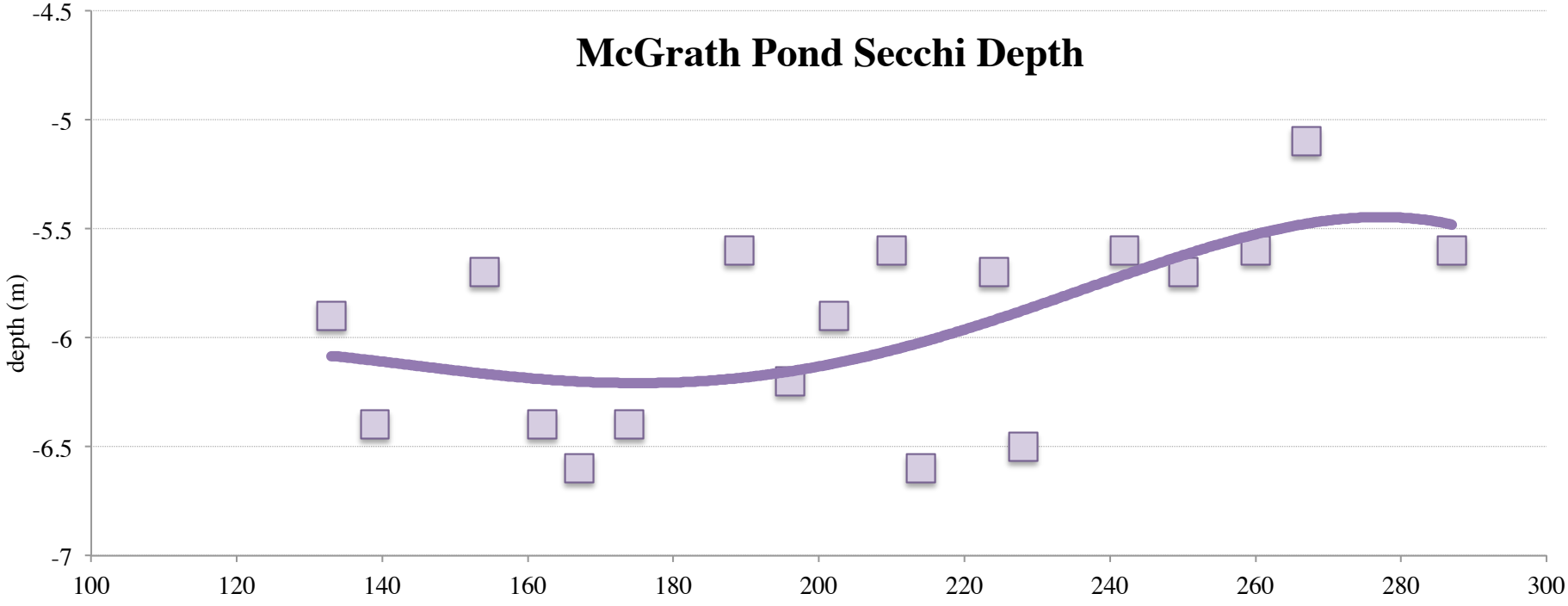

McGrath Pond Apparent Oxygen Utilization
Julian Day
125
145
165
185
205
225
245
265
285
5000
0
-5000
-10000
-15000
-20000
Oxygen Defecit (Kilograms)
0.29 metric tons / Day
y = -291.51x + 40174
R² = 0.97559

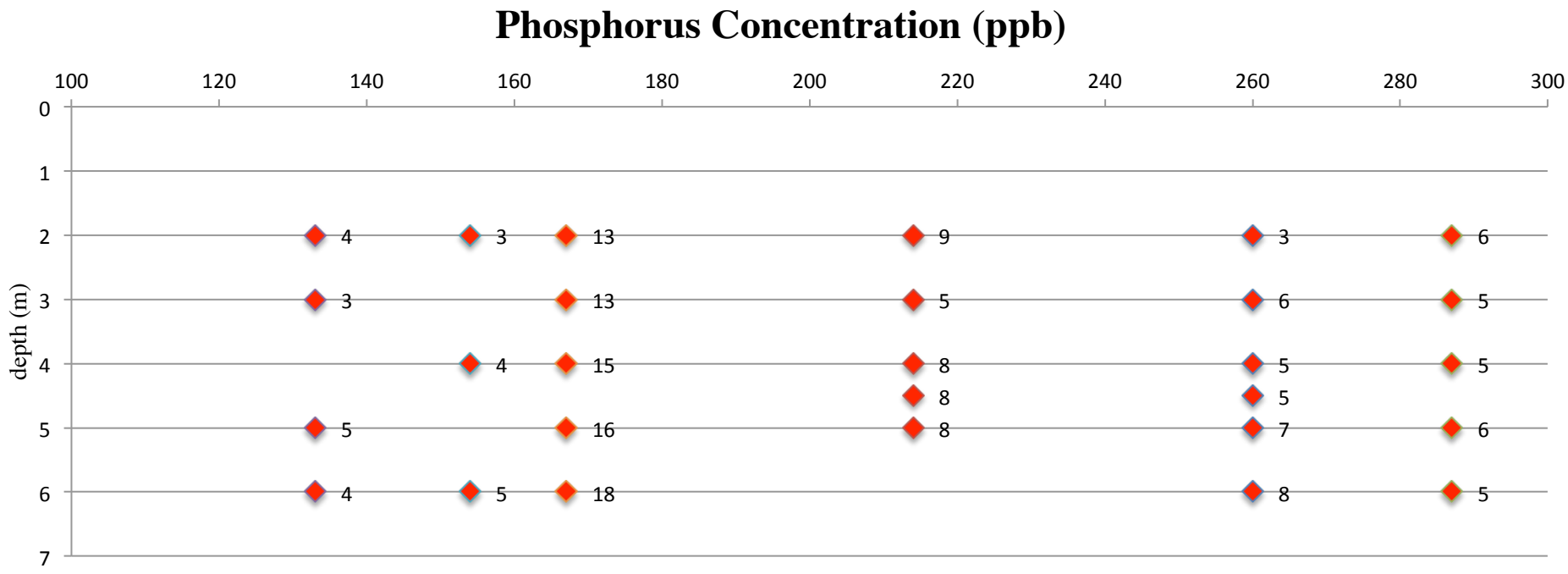
# McGrath Pond Anoxic Sediment (Fraction of Lake Area)




McGrath Pond Iron Concentration (ppb)
depth (m)
100 120 140 160 180 200 220 240 260 280 300
0 1 2 3 4 5 6 7
31 30 38 27 9 3
32 36 10 11 3
28 36 17 14 3
12 29
36 50 78 22 2
38 36 51 49 9

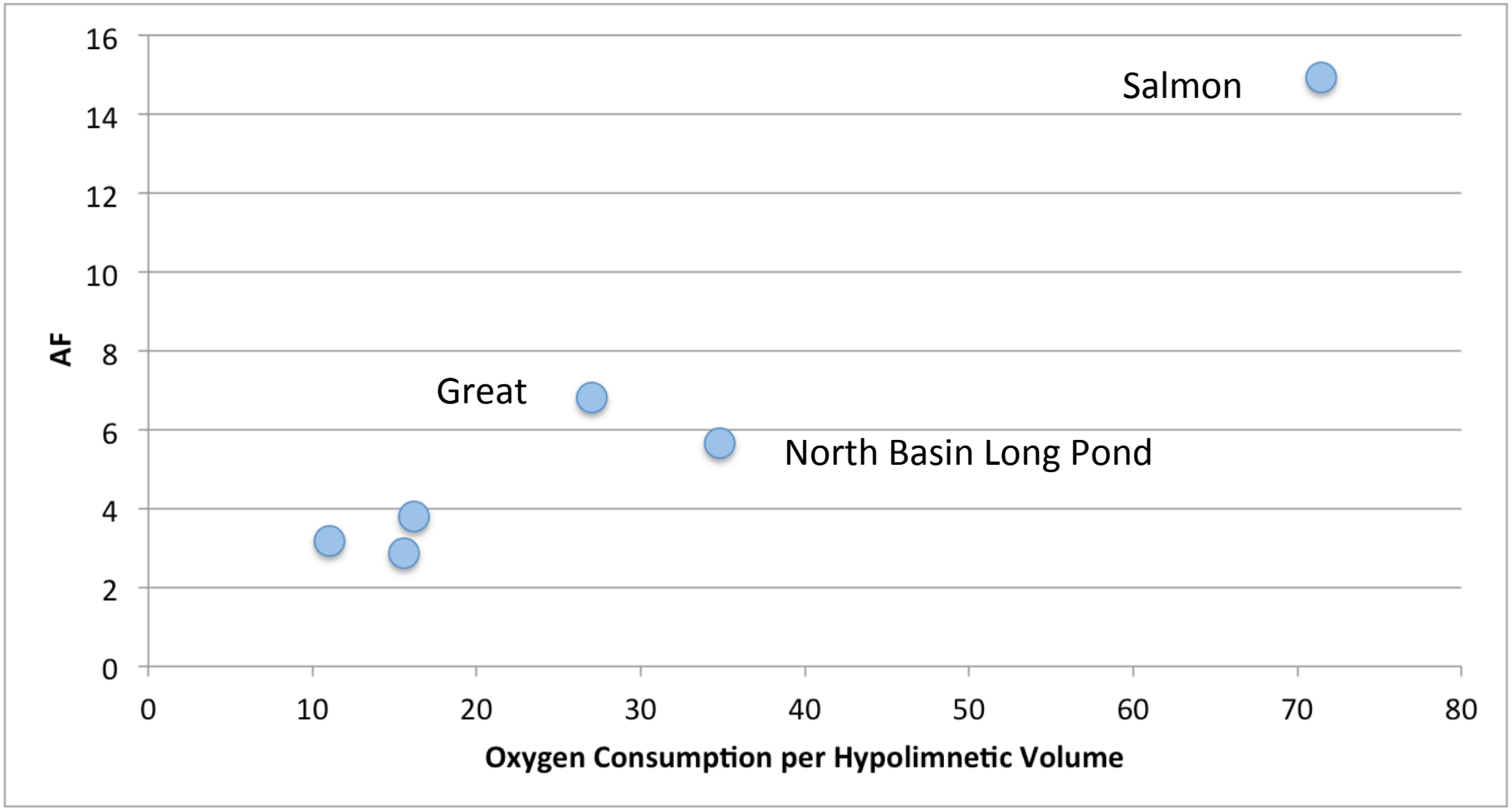

Aluminum Concentration (ppb)
depth (m)
100 120 140 160 180 200 220 240 260 280 300
0 1 2 3 4 5 6 7
28 24 31 27 26 27
30 25 13 27 6
23 28 13 36 6
11 25
30 30 9 32 12
32 28 30 34 16


McGrath Pond Secchi Depth
depth (m)
-4.5
-5
-5.5
-6
-6.5
-7
100
120
140
160
180
200
220
240
260
280
300

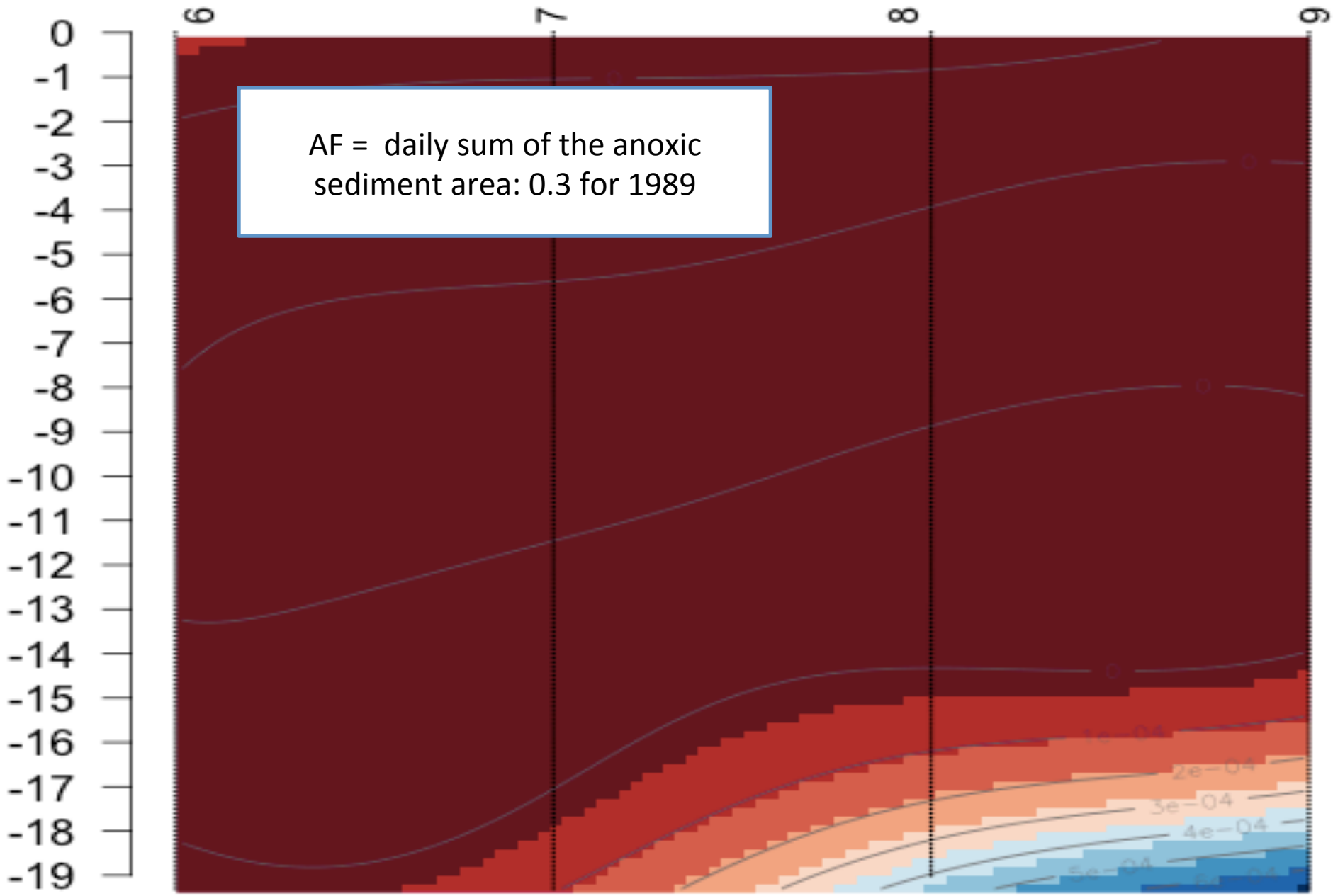

Phosphorus Concentration (ppb)
depth (m)
100
120
140
160
180
200
220
240
260
280
300
0
1
2
3
4
5
6
7
4
3
13
9
3
6
3
13
5
6
5
4
15
8
5
5
8
5
5
16
8
7
6
4
5
18
8
5

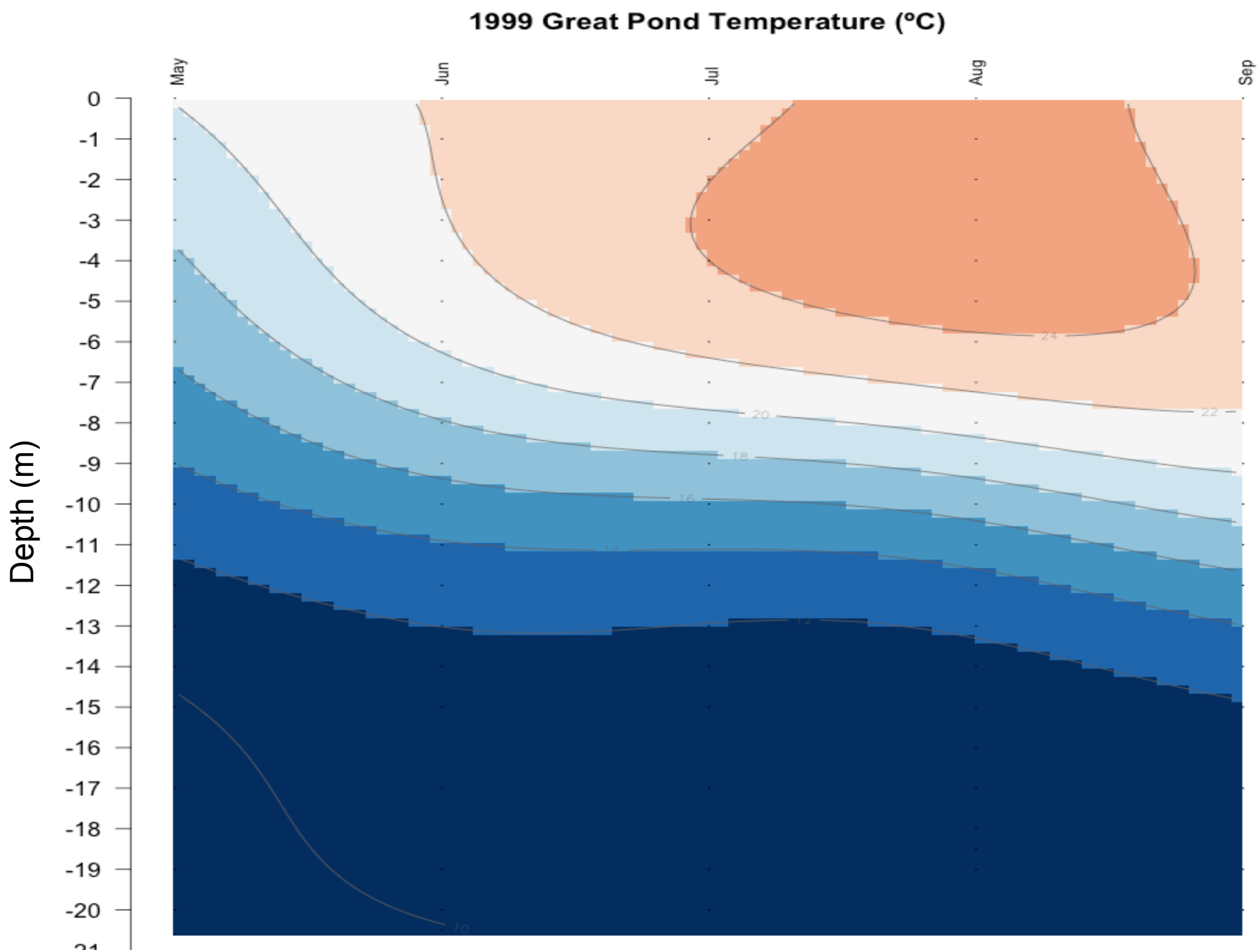
# Belgrade Lakes Data 2015

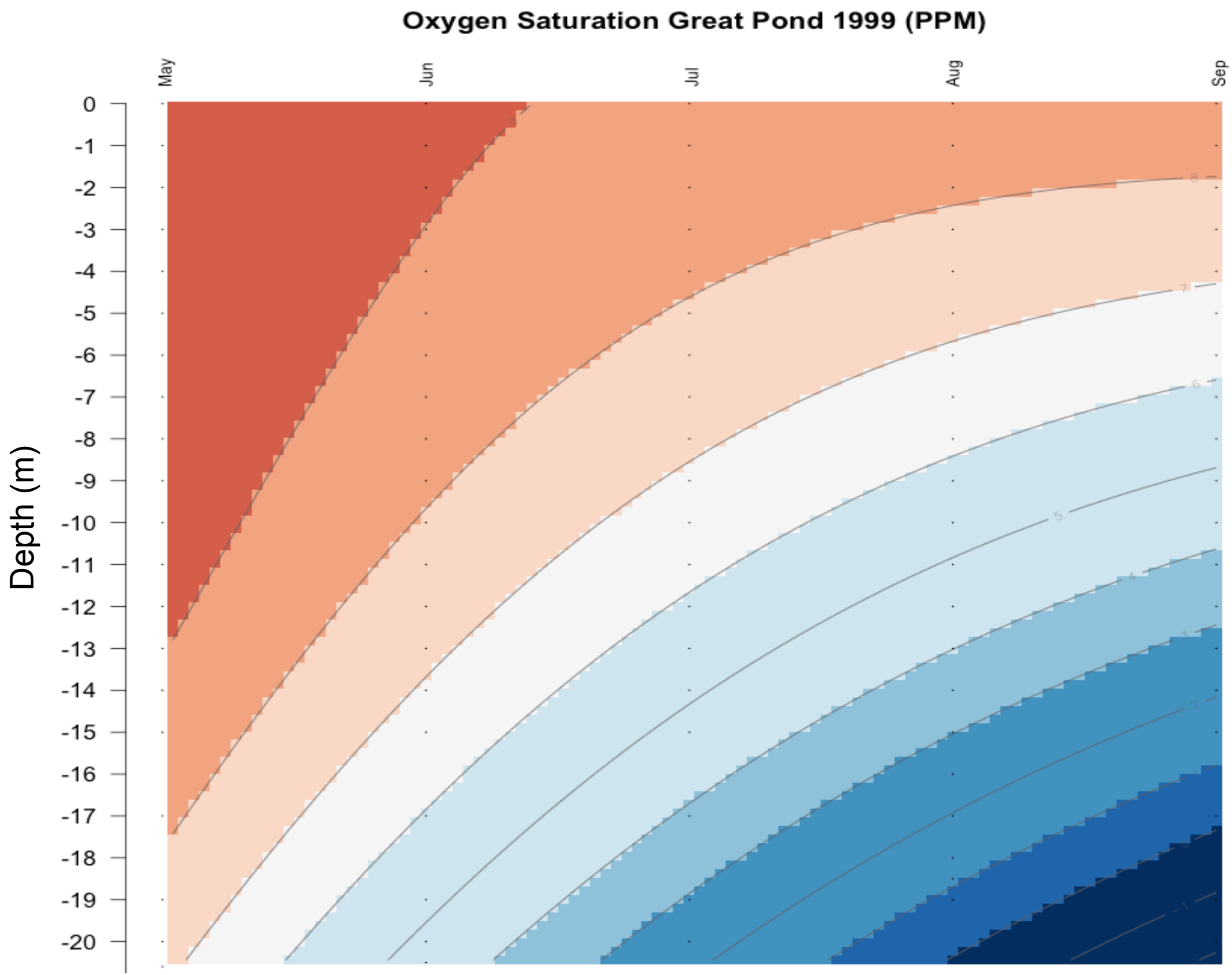
| LAKE | Area km^2 | Mean Depth m | Maximum Depth m | Volume Mm^3 | Morphometric Index m/km | residence time (months) | thermocline depth meters | O2 consuption kg/day | AF area day | O2/volume kg/d Mm^3 | O2/area kg/d km^2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Long Pond (North) | 5.1 | 8 | 20 | 38 | 3.3 | 3 | 6 | 480 | 5.67 | 35 | 314 |
| Long Pond (South) | 4.1 | 8 | 30 | 31 | 3.7 | 3 | 6.5 | 240 | 3.81 | 16 | 182 |
| Great Pond | 34.5 | 6 | 21 | 241 | 1.1 | 28 | 6 | 2080 | 6.8 | 27 | 183 |
| Messalonskee Lake | 14.9 | 10 | 34 | 136 | 2.6 | 8 | 8 | 600 | 3.17 | 11 | 115 |
| North Pond | 10.2 | 4 | 6 | 41 | 1.2 | 12 | 7 | 1000 | | 25 | 444 |
| McGrath Pond | 1.9 | 5 | 8 | 8 | 3.5 | 17 | 7 | 290 | | 36 | 639 |
| East Pond | 6.9 | 5 | 8 | 34 | 2.1 | 48 | 7 | 525 | 2.88 | 16 | 270 |
| Salmon Pond (Ellis Pond) | 2.8 | 7 | 17 | 20 | 4.2 | 22 | 6.5 | 500 | 14.93 | 43 | 381 |



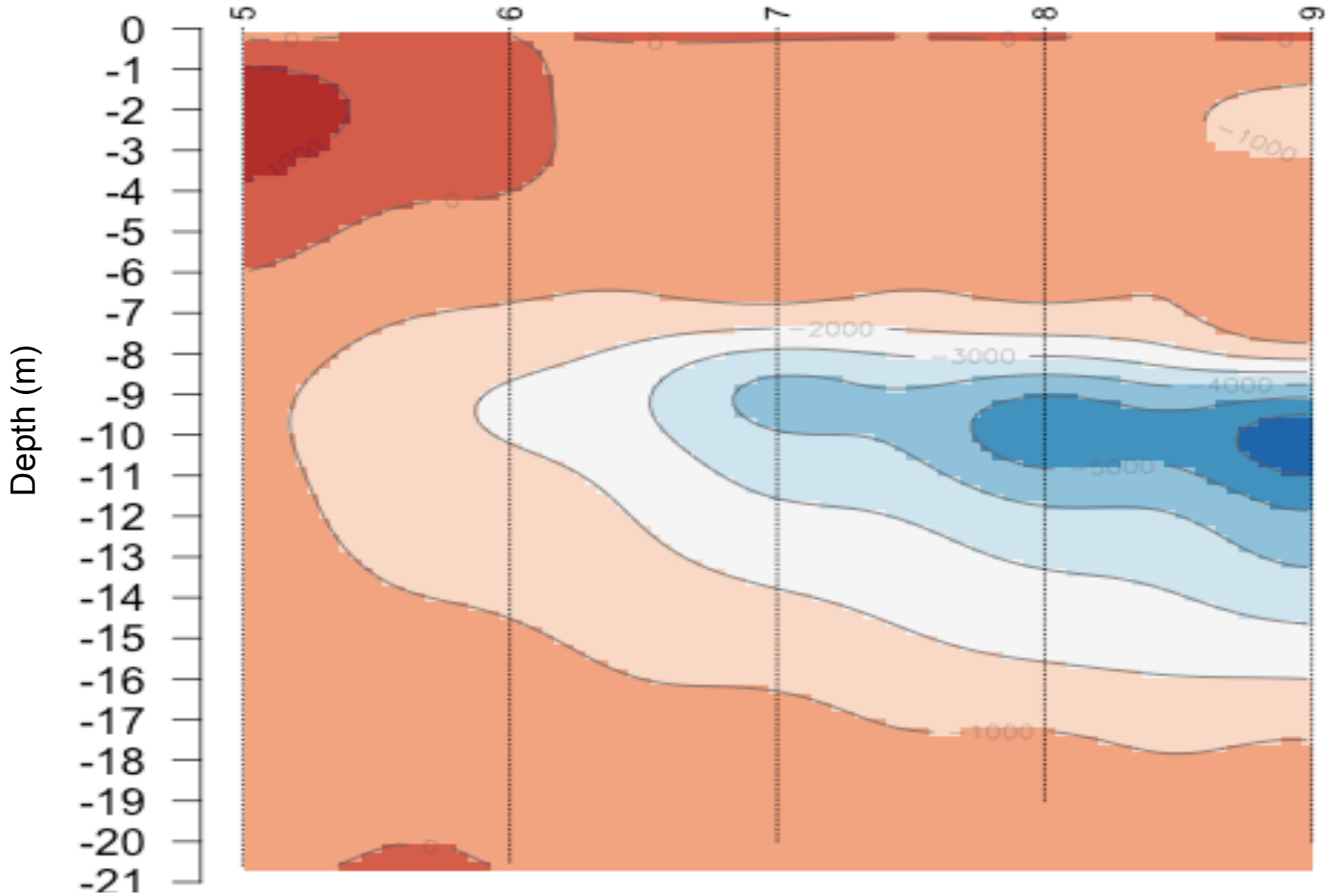
# 1989 Great Pond Anoxic Sediment (Fraction of Lake Area)



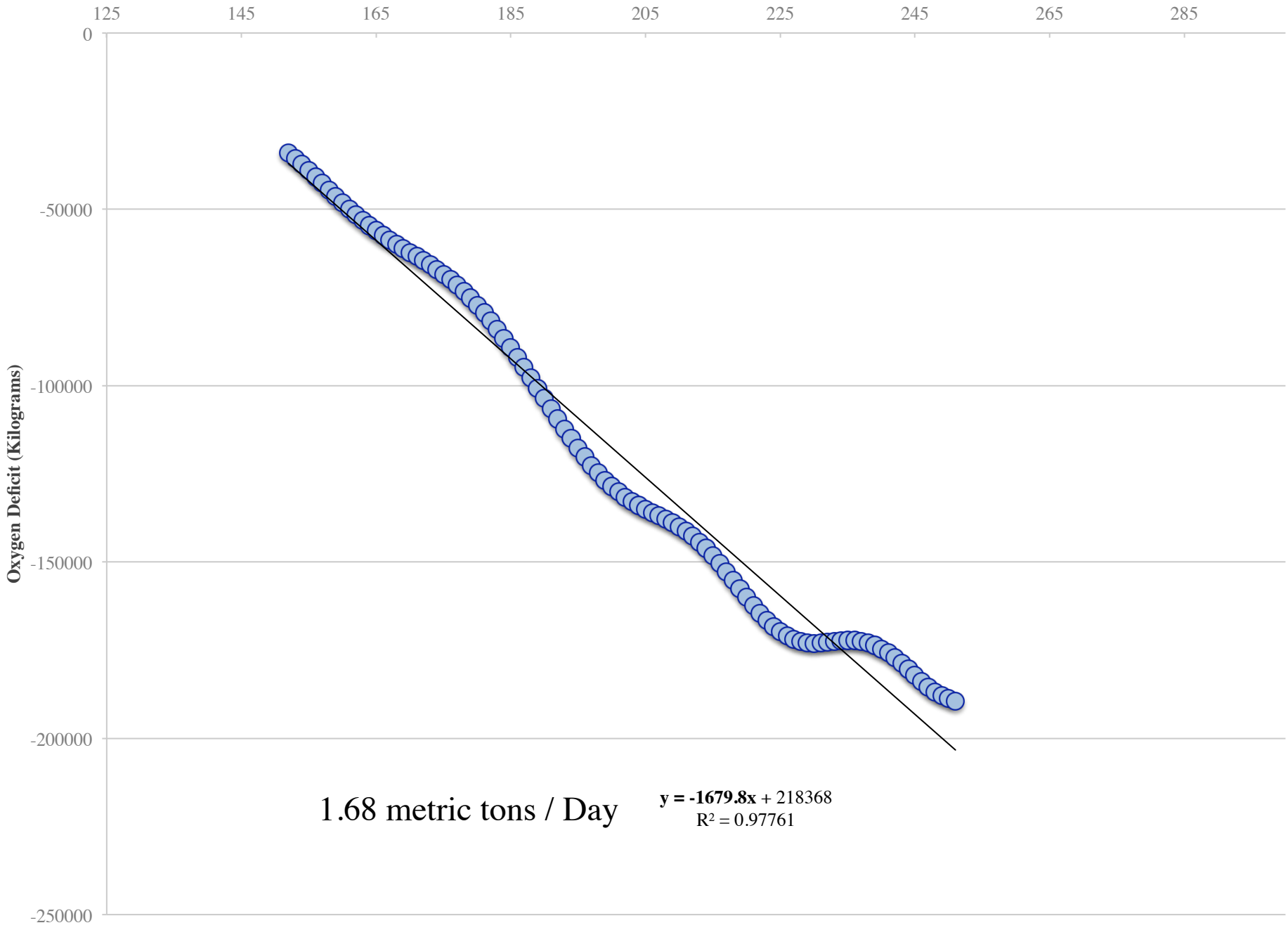

1999 Great Pond Temperature (°C)
May
Jun
Jul
Aug
Sep
Depth (m)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
24
22
20
18
16
14
12
10


Oxygen Saturation Great Pond 1999 (PPM)
May
Jun
Jul
Aug
Sep
Depth (m)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20

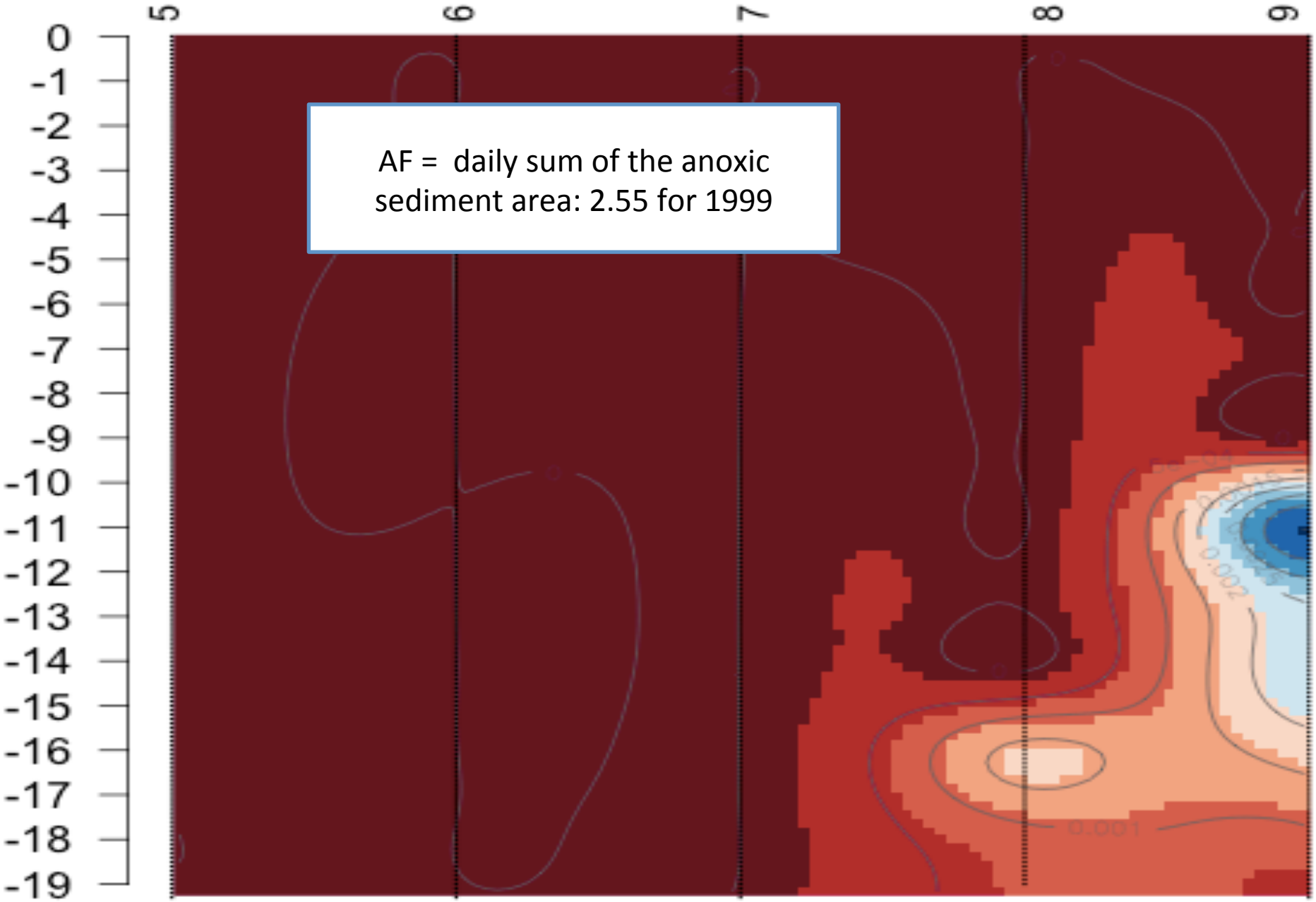
# 1999 Great Pond Oxygen Anomaly (kg)



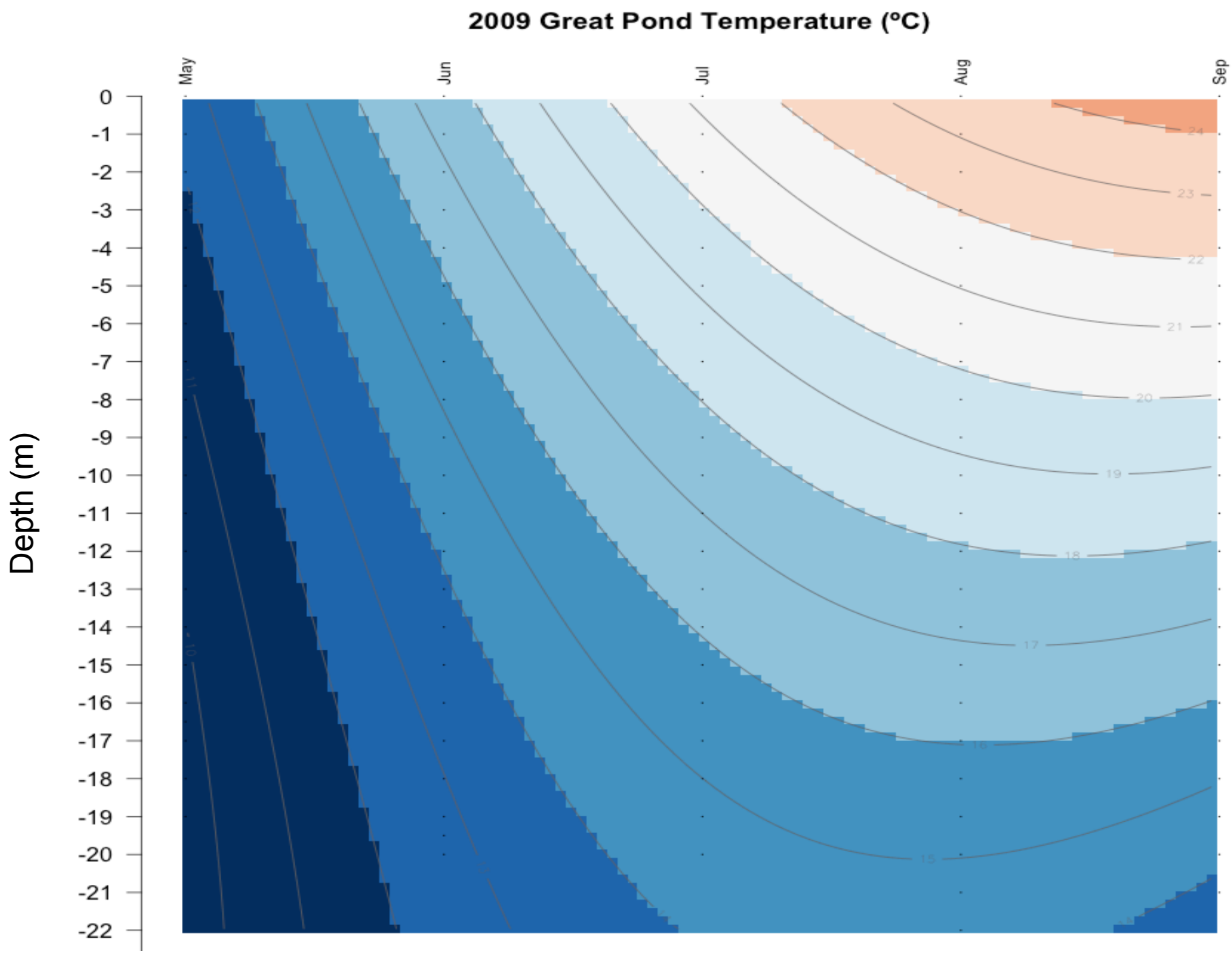
# 1999 Oxygen Consumption in Great Pond

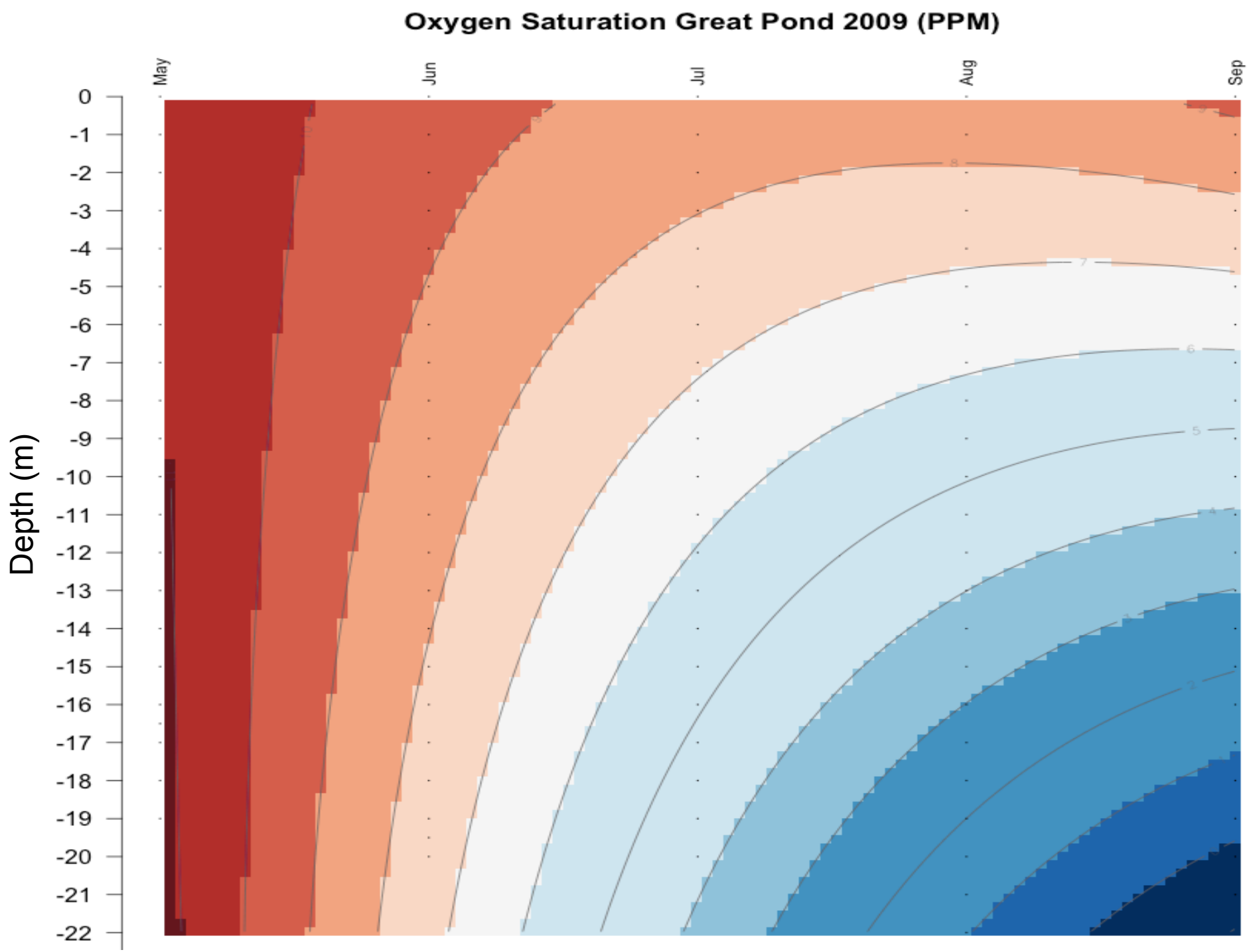


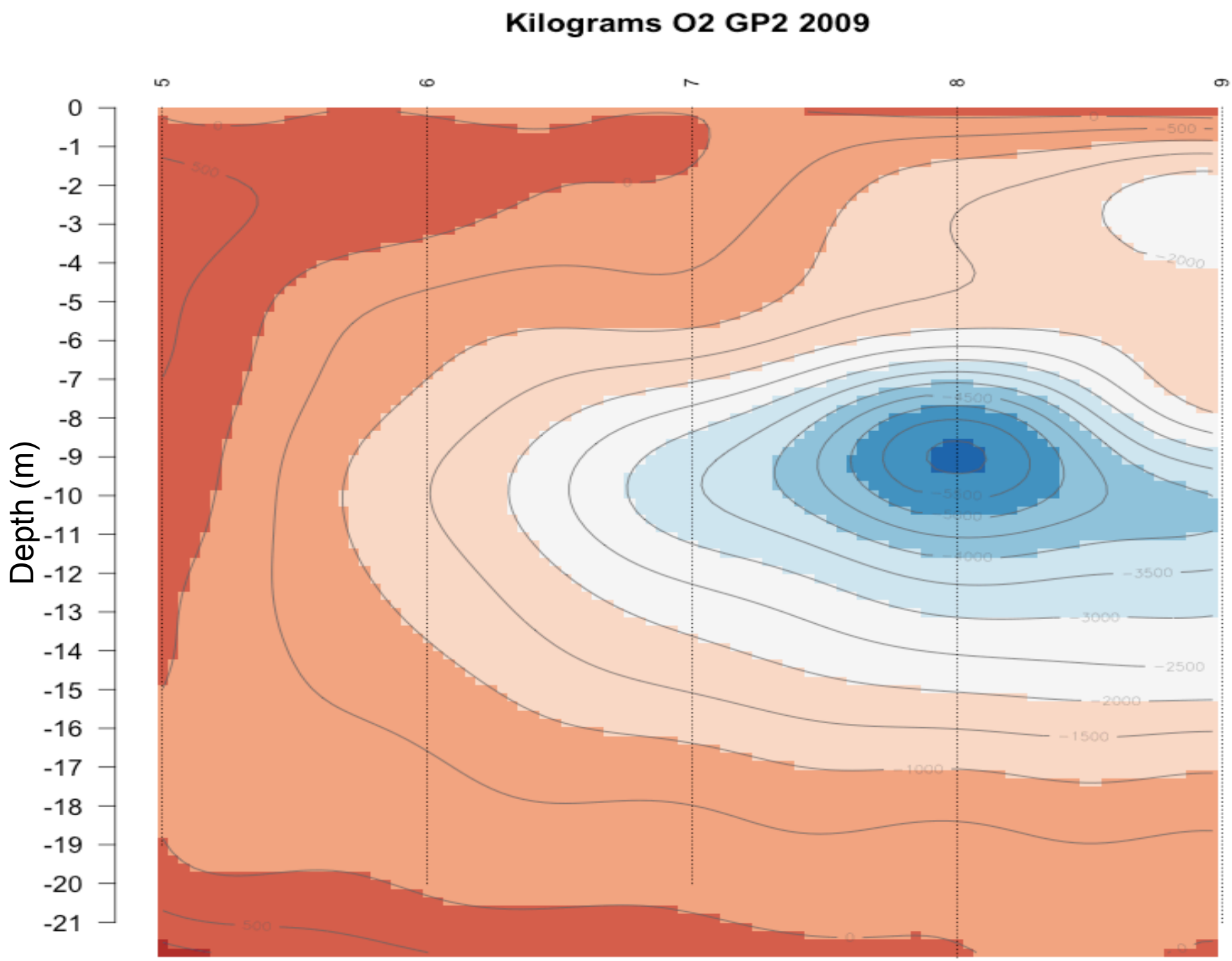
# 1999 Great Pond Anoxic Sediment (Fraction of Lake Area)

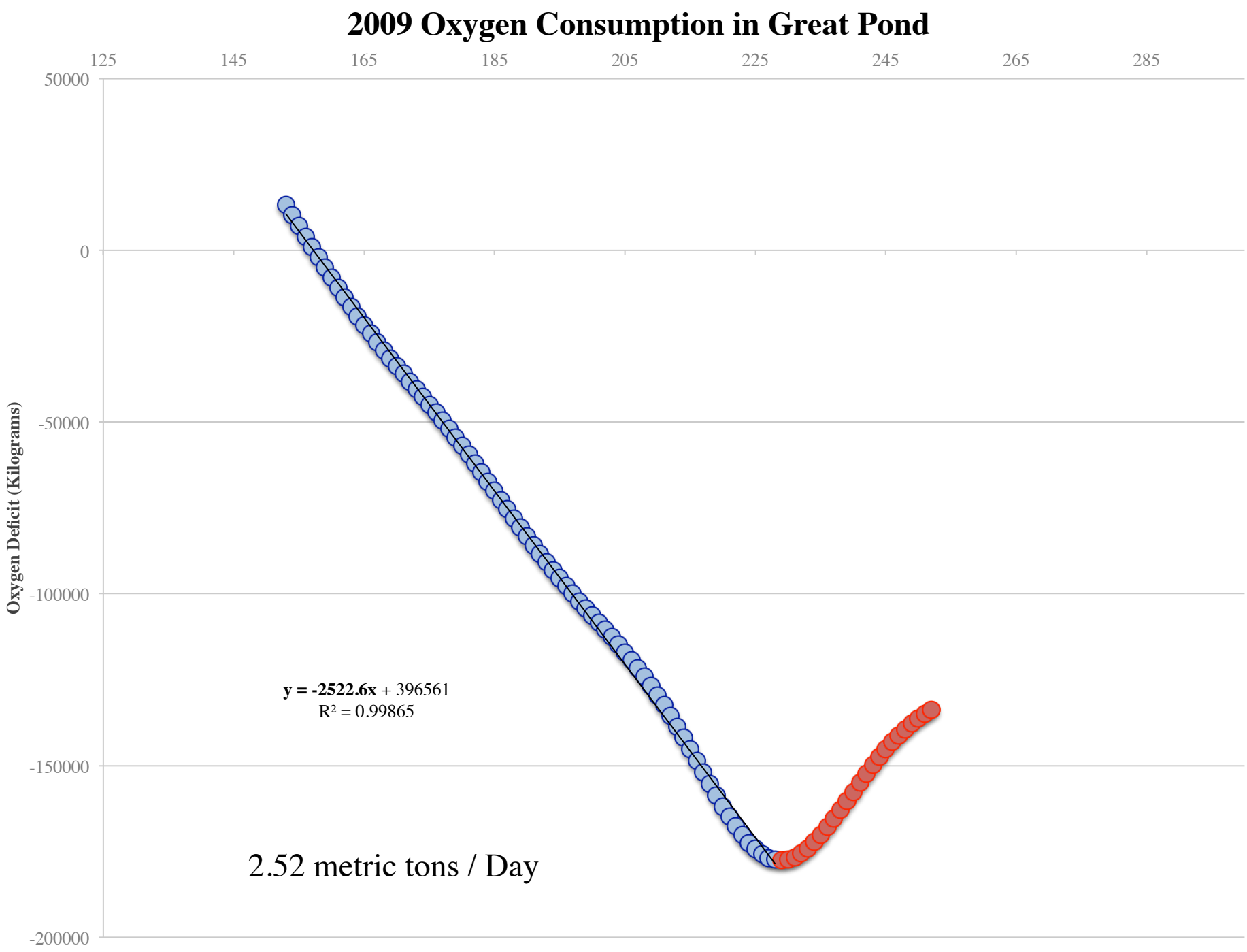



AF = daily sum of the anoxic sediment area: 2.55 for 1999


2009 Great Pond Temperature (ºC)
May
Jun
Jul
Aug
Sep
Depth (m)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
-22
24
23
22
21
20
19
18
17
16
15


Oxygen Saturation Great Pond 2009 (PPM)
May
Jun
Jul
Aug
Sep
Depth (m)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
-22


Kilograms O2 GP2 2009
Depth (m)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
5
6
7
8
9
500
0
-500
-2000
-4500
-5000
-5500
-4000
-3500
-3000
-2500
-2000
-1500
-1000


2009 Oxygen Consumption in Great Pond
125
145
165
185
205
225
245
265
285
50000
0
-50000
-100000
-150000
-200000
Oxygen Deficit (Kilograms)
y = -2522.6x + 396561
R² = 0.99865
2.52 metric tons / Day

# 2009 Great Pond Anoxic Sediment (Fraction of Lake Area)