Water Quality Study of Coes Reservoir, Worcester, MA 2000

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ABSTRACT:
A study of the water quality of Coes Reservoir was done in the fall of 2000. The resulting data was analyzed to determine the actual value of mean pH, determine confidence intervals for nitrate levels at each site, investigate the existence of differences in mean secchi disk depth among sites, determine the relationship between water and air temperature, and determine the association, if any, between wind speed and water clarity.

INTRODUCTION:
A water quality analysis was conducted for Coes Reservoir from mid-September to late October 2000. The analysis measured such characteristics as air and water temperature, pH, nitrate level, wind speed, clarity, and secchi disk depth. The data recorded was then statistically analyzed to determine the characteristics of the reservoir. Finally, the data for Coes Reservoir were compared to those for other water bodies in the Northeast. The data for this study were collected over a period of several weeks in the fall of 2000.

METHODS:
In order to examine whether Coes Reservoir was acidic or basic, a t-test was conducted to determine if the mean pH was statistically different from 7. The null hypothesis for this test was that the mean pH was not statistically different from 7. The alternative hypothesis was simply that the mean pH was statistically different from 7. A two sided test was used. There were 35 observations and 34 degrees of freedom.

90% confidence intervals were created for mean nitrate level of each of the 11 sites. T-values were used for all 11 intervals.

Site	Degrees of freedom
Boat 1	5
Boat 2	5
Boat 3	5
Botany Bay	3
K of C	3
Liquor & Bowl	3
New Beach	3
New Houses	3
Pontius	4
Road Beach	3
Spillway	3

A t-test was performed to determine if there was any statistical difference in mean secchi disk depth between the Boat 1 and Boat 2 sites. An unpaired test was used because there was missing data from the Boat 1 site. This was a two-sided test with 10 observations for Boat 2 and 8 observations for Boat 1 for a total of 18 observations. The null hypothesis for this test was that there was no statistically significant difference between the two sites. The alternative hypothesis was that there was a statistically significant difference between the two sites.

A regression analysis was carried out to examine the effect of air temperature on water temperature.

A chi-square test was used to examine how closely wind speed and water clarity are related. The null hypothesis for this test was that there is no association between these two variables. The alternative hypothesis was that there is an association.

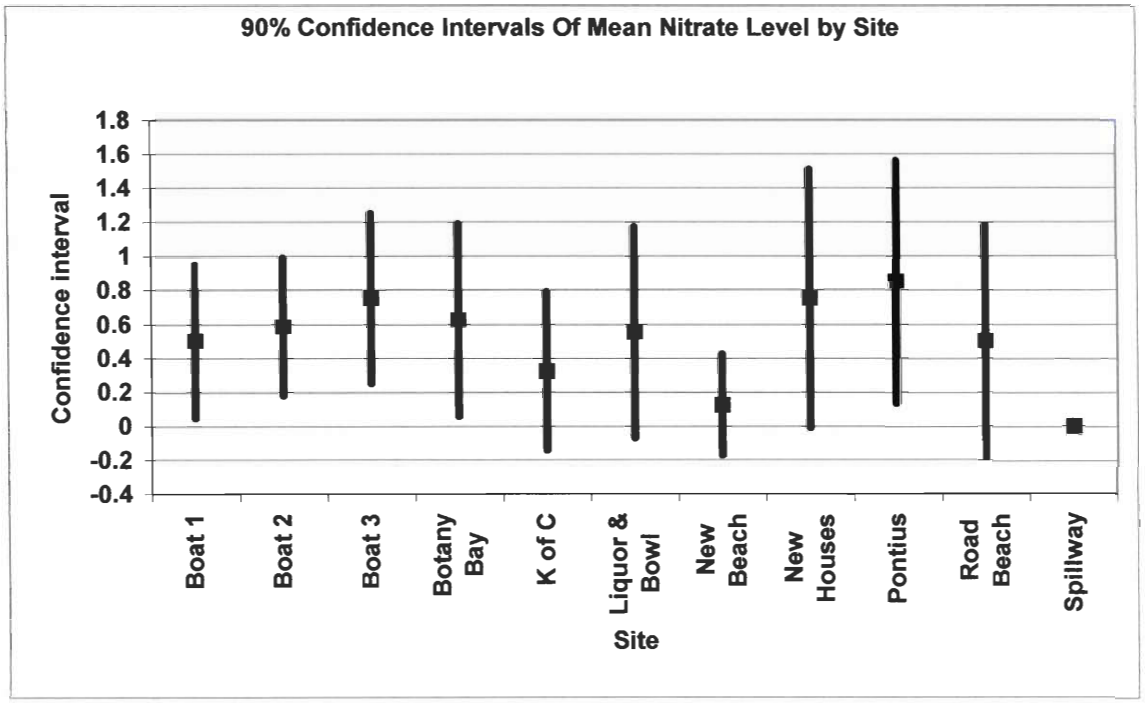
Finally, the mean secchi depth for Coes Reservoir was compared to the average depths for other water bodies in the Northeast. The Northeast in this case is defined as New England plus New York State. The mean value for all tested water bodies in the Northeast, excluding Coes, was first calculated. The mean for Coes was calculated in two ways. It was first calculated with all data included. It was then recalculated leaving out outliers, as these were generally attributed to measurement error.

RESULTS:
For the examination of pH, the following was found: at the 90% confidence interval the t-statistic was –1.57 and the critical value was 1.69. Based on this information, the null hypothesis that the mean pH is not statistically different from 7 was accepted. The P-value for this test was .13.

	pH	*Average*
Mean	6.914285714	7
Variance	0.104201681	0
Observations	35	35
Hypothesized Mean Difference	0	
df	34	
t Stat	-1.570904814	
P(T<=t) one-tail	0.06273283	
t Critical one-tail	1.306950708	
P(T<=t) two-tail	0.125465661	
t Critical two-tail	1.690923455	

The confidence intervals for each site are shown in the chart below. If the null hypothesis that the mean nitrate level was .9 were to be tested at an alpha level of .10, it could be rejected at the K of C, New Beach, and Spillway sites. This is because .9 does not fall in the 90% confidence interval for these sites.

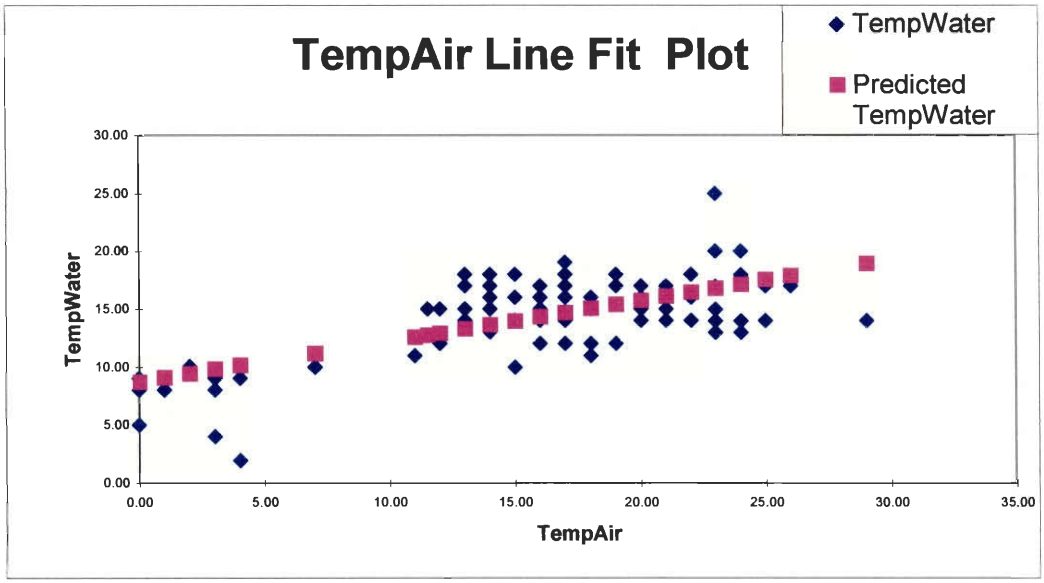
Site	Confidence Interval	Degrees of freedom
Boat 1	.05-.95	5
Boat 2	.18-.99	5
Boat 3	.25-1.25	5
Botany Bay	.06-1.19	3
K of C	-.14-.79	3
Liquor & Bowl	-.07-1.17	3
New Beach	-.17-.42	3
New Houses	-.01-1.51	3
Pontius	.14-1.56	4
Road Beach	-.18-1.18	3
Spillway	0-0	3



The t-test to determine whether there was a statistically significant difference between the Boat 1 and Boat 2 sites yielded a t-statistic of -.215 and a t-critical of 1.75. This information allowed us to accept our null hypothesis that there is no statistically significant difference at the 90% confidence interval. The P-value for this test was .833.

	SecchiDisk1	*SecchiDisk2*
Mean	2.55875	2.764
Variance	2.2678125	6.287293333
Observations	8	10
Hypothesized Mean Difference	0	
df	15	
t Stat	-0.214900155	
P(T<=t) one-tail	0.416369785	
t Critical one-tail	1.340605422	
P(T<=t) two-tail	0.83273957	
t Critical two-tail	1.753051038	

The equation of the regression line for the regression analysis of the effect of air temperature on water temperature was y=.35x+8.68. The slope of the relationship is statistically different from zero, as evidenced by the extremely low p-value. For every degree of increase in air temperature, water temperature increases by .35 degrees. If the air temperature for a given day was known to be 30°C the predicted water temperature according to the regression would be 19.18°C. The R-square value for the regression is .46. Because this is approximately halfway between 0 and 1, we can say that there is a loose relationship between air and water temperatures.



For the chi-square test to examine the association between wind speed and water clarity, the chi-square (observed) was 15.53 and the chi-square (critical) was 16.92. Because the observed is not greater than the critical, we can accept the null hypothesis. The associated p-value is .08. Because we have determined that there is no association between wind speed and clarity, we can not say that any particular wind speed is associated with high or low clarity.

Observed

Wind \ Clarity	0.00	1.00	2.00	3.00	Total
0.00	3.00	4.00	10.00	5.00	22.00
1.00	6.00	17.00	13.00	17.00	53.00
2.00	4.00	8.00	4.00	11.00	27.00
3.00	0.00	6.00	0.00	2.00	8.00
Total	13.00	35.00	27.00	35.00	110.00

Expected

Wind \ Clarity	0.00	1.00	2.00	3.00	Total
0.00	2.60	7.00	5.40	7.00	22.00
1.00	6.26	16.86	13.01	16.86	53.00
2.00	3.19	8.59	6.63	8.59	27.00
3.00	0.95	2.55	1.96	2.55	8.00
Total	13.00	35.00	27.00	35.00	110.00

Difference

Wind \ Clarity	0.00	1.00	2.00	3.00	Total
0.00	0.40	-3.00	4.60	-2.00	0.00
1.00	-0.26	0.14	-0.01	0.14	0.00
2.00	0.81	-0.59	-2.63	2.41	0.00
3.00	-0.95	3.45	-1.96	-0.55	0.00
Total	0.00	0.00	0.00	0.00	0.00

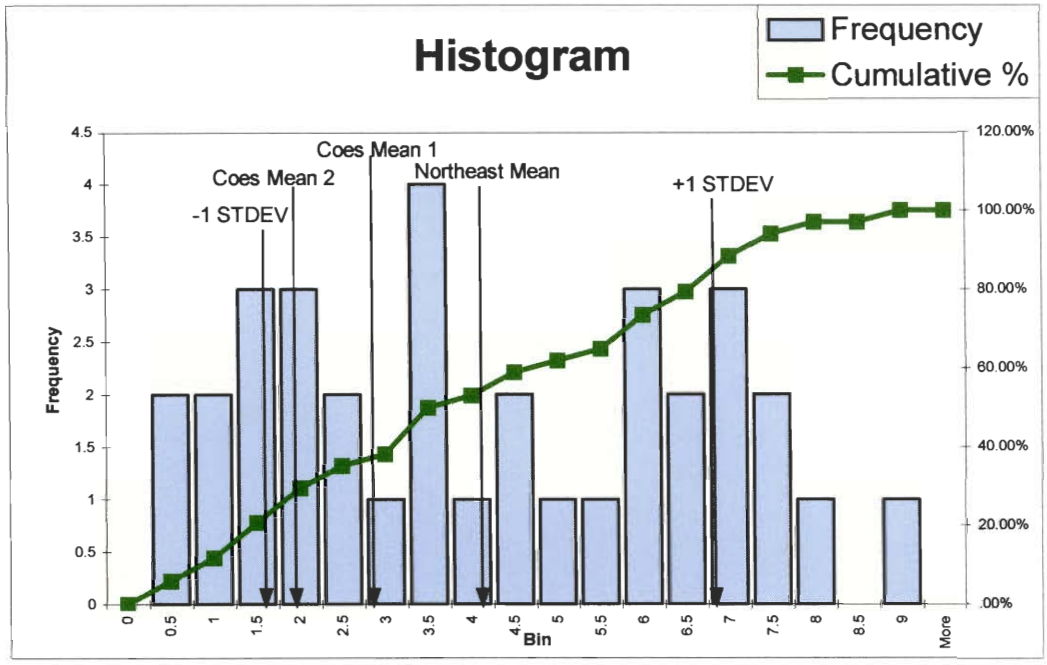
Difference^2/Expected

Wind \ Clarity	0.00	1.00	2.00	3.00	Total
0.00	0.06	1.29	3.92	0.57	5.84
1.00	0.01	0.00	0.00	0.00	0.01
2.00	0.21	0.04	1.04	0.68	1.96
3.00	0.95	4.69	1.96	0.12	7.71
Total	1.22	6.02	6.92	1.36	15.53

Chi-Square (observed):	15.53
Chi-Square (critical):	16.92
df:	9.00
P-Value:	0.08

In comparing the Coes data to other data for the Northeast, it was found that the mean value for all tested water bodies in the Northeast, excluding Coes, was 3.99 meters. With all data included, the Coes mean secchi depth was determined to be 2.62 meters. Leaving out outliers, it was calculated to be 1.72. The standard deviation for the Northeast data was 2.52. Therefore, the mean value for Coes reservoir, when calculated either way, falls within one standard deviation of the Northeast mean.

Northeast Data	
Mean	3.988529412
Standard Error	0.43095759
Median	3.54
Mode	3.31
Standard Deviation	2.512892975
Sample Variance	6.314631105
Kurtosis	-1.254029973
Skewness	0.209291333
Range	8.68
Minimum	0.27
Maximum	8.95
Sum	135.61
Count	34
Largest(1)	8.95
Smallest(1)	0.27
Confidence Level(95.0%)	0.876790504



DISCUSSIONS:

The fact that the mean pH of Coes Reservoir was not found to be statistically different from 7 shows that the water is very close to neutral. Some data was missing for this test because the measurement of pH was not implemented until data collection was already underway. Also, pH was not measured at the boat sites. Ideally, a more precise and less subjective method of measuring pH than test strips would be used, therefore ensuring greater accuracy in the data.

Again, some data was missing from the nitrate confidence intervals because measurement was not implemented until data collection was already underway. This is another case where a more accurate method of measurement would be ideal, as the strips used were very vague, and left a good deal up to the judgment of the experimenter.

Naturally, secchi disk data only existed for the boat sites. The secchi disk data has a large range. This may be the result of measurement error, specifically the inexperience of the experimenters at using the secchi disk. Additionally, some error may be inherent to the design of the view tube, as its grooved shape causes ripples inside the viewing area and obstructs the view of the disk. Some of the outliers may have exceeded the depth of the lake.

Due to the high specific heat of water, the water will cool down much more slowly than the air. This is probably the reason the association between air temperature and water temperature in the regression analysis is not closer. The drop in temperature of the water will actually lag behind the drop in temperature of the air. Therefore sudden, unseasonal drops in air temperature followed by increases to normal seasonal air temperatures may not have much of an effect on water temperature. Because of this fact, the predicted water temperature of 19.18°C when the air temperature is 30°C may not be very useful.

The fact that both of the variables in the chi-square test were qualitative opened this problem up to a great deal of subjectivity. The scale used was limited in categories and rather vague as to what the category boundaries were. Ideally, an anemometer would be used. In absence of this, however, a more detailed scale with explanations of conditions defining each wind speed category would reduce the amount of subjectivity in the data.

The comparison of the Coes Reservoir secchi disk data to data for the entire Northeast ran into the same problems as the test of the existence of a statistically significant difference in mean secchi disk depth between the Boat 1 and Boat 2 sites. Our results did show that Coes Reservoir is similar in mean secchi disk depth to other water bodies in the Northeast.

CONCLUSIONS:

This study was conducted to examine several characteristics of Coes Reservoir. These characteristics were analyzed in depth through statistical measures. It was determined through analyzing secchi depths of Coes Reservoir and other Northeast water bodies that Coes is similar to the other water bodies in this characteristic. Because this study was conducted over a relatively short period with minimal and subjective techniques, its findings should be considered preliminary.