Modeling Support for James River Chlorophyll Study

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Outline

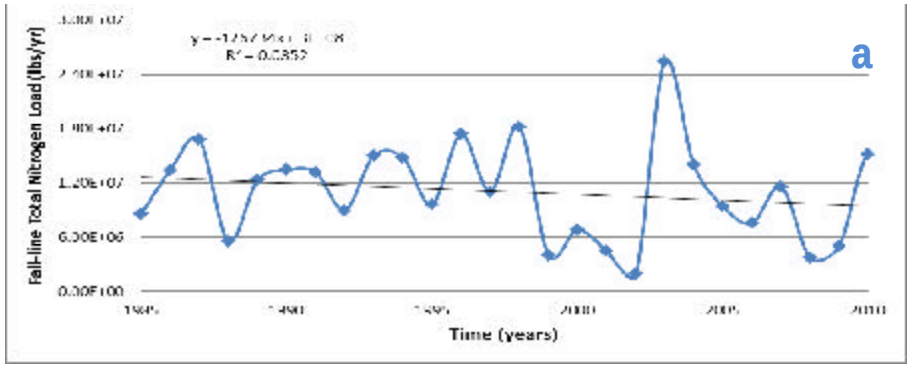
- Long-term trend analysis of annual loading above fall line
- Long-term trend analysis for observations
- Correlation analysis of phytoplankton with respect to TN,TP, and environmental variables

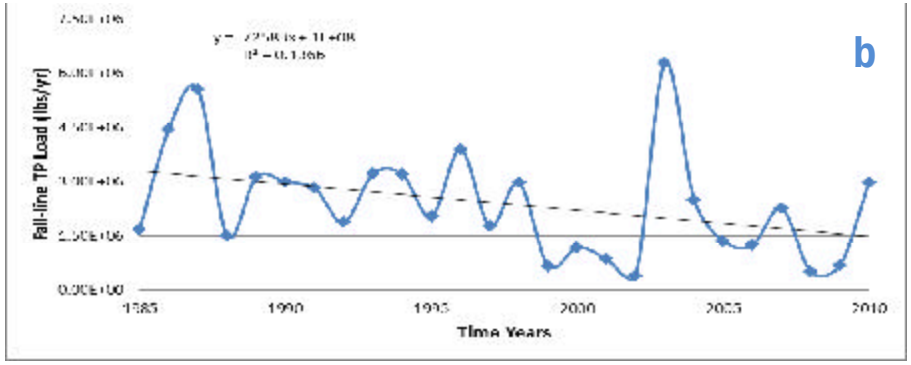
Long-term trend analysis

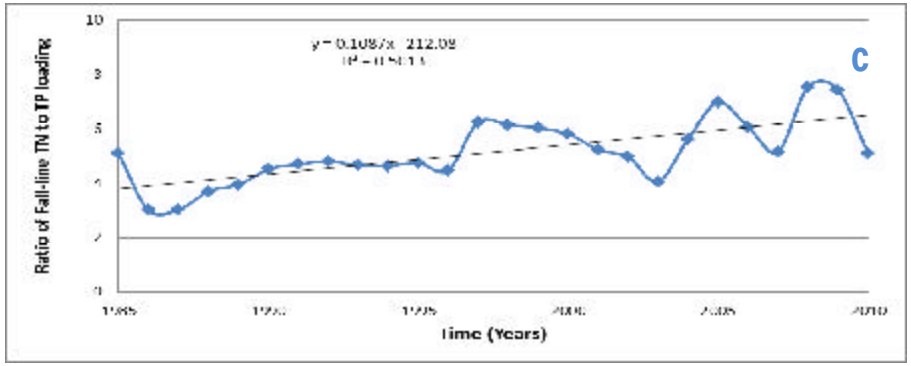
- Examine if there are any long-term nutrient loading changes
- Examine whether resulting in change of phytoplankton, N:P ratio, species compositions, and abundance

Annual loading above fall line

- U.S. Geological Survey's River Input Monitoring program (1995-2010)
- Trend
  - The slope of the TN is not statistically significant (p=0.36)
  - slope of TP is statistically significant (p=0.06), the R^2 is fairly small, explaining only 13% of the variance
  - significant change in the ratio of TP:TN (p<0.001) and the R^2 is larger (>0.5)
- Potential nitrogen limitation for phytoplankton growth







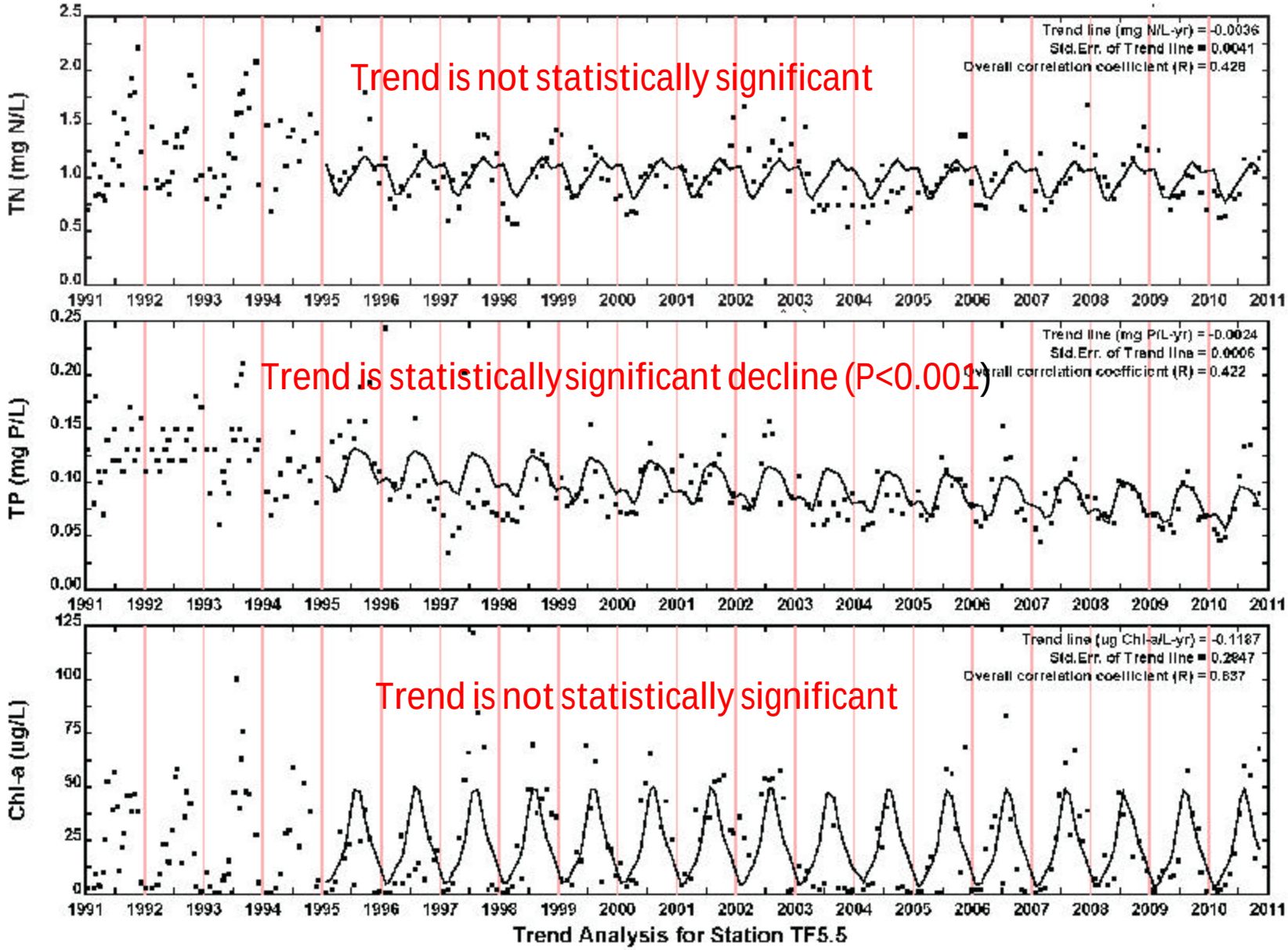
Long-term analysis for observations

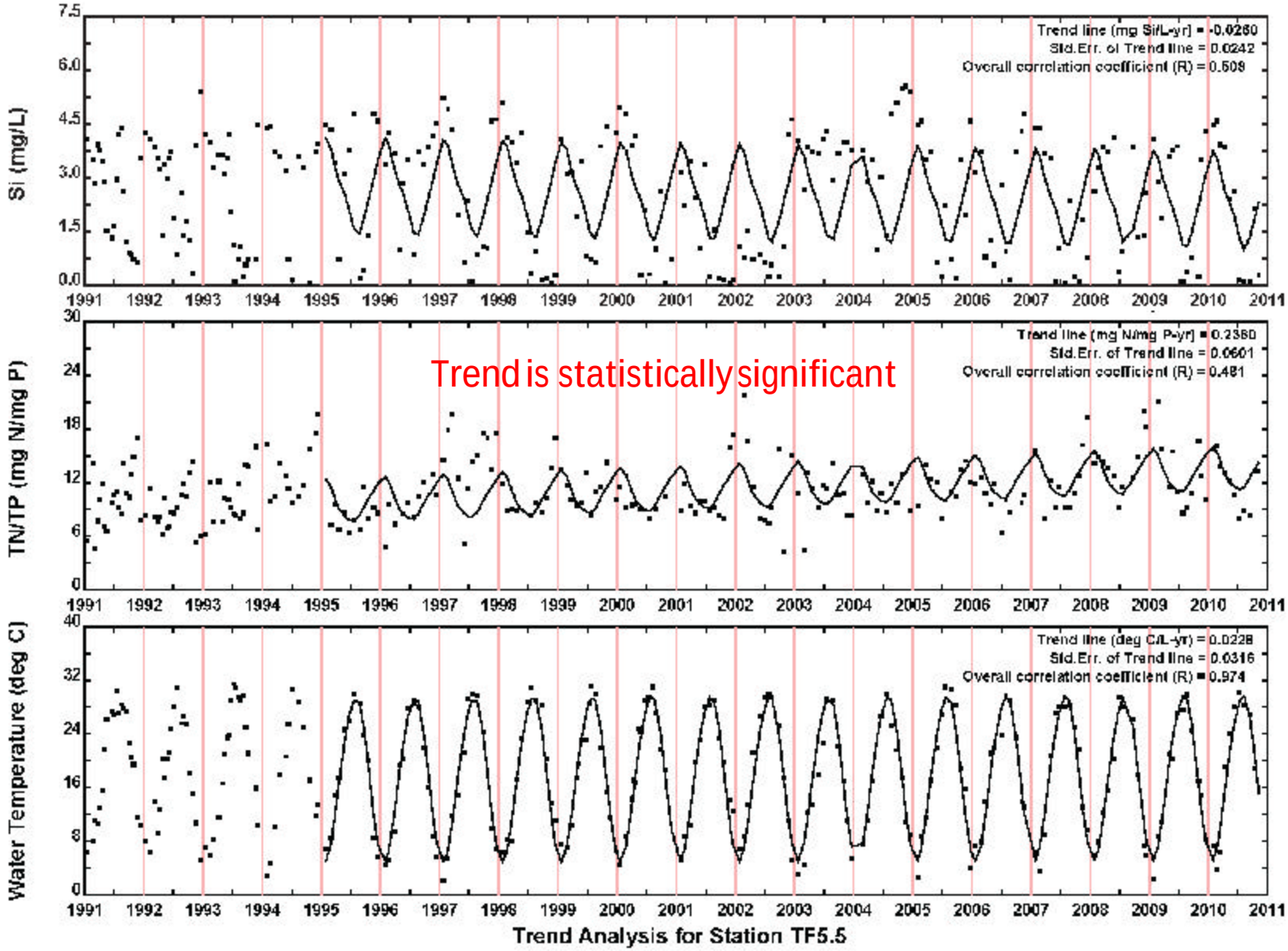
Consider influence of annual and seasonal variations on trend analysis

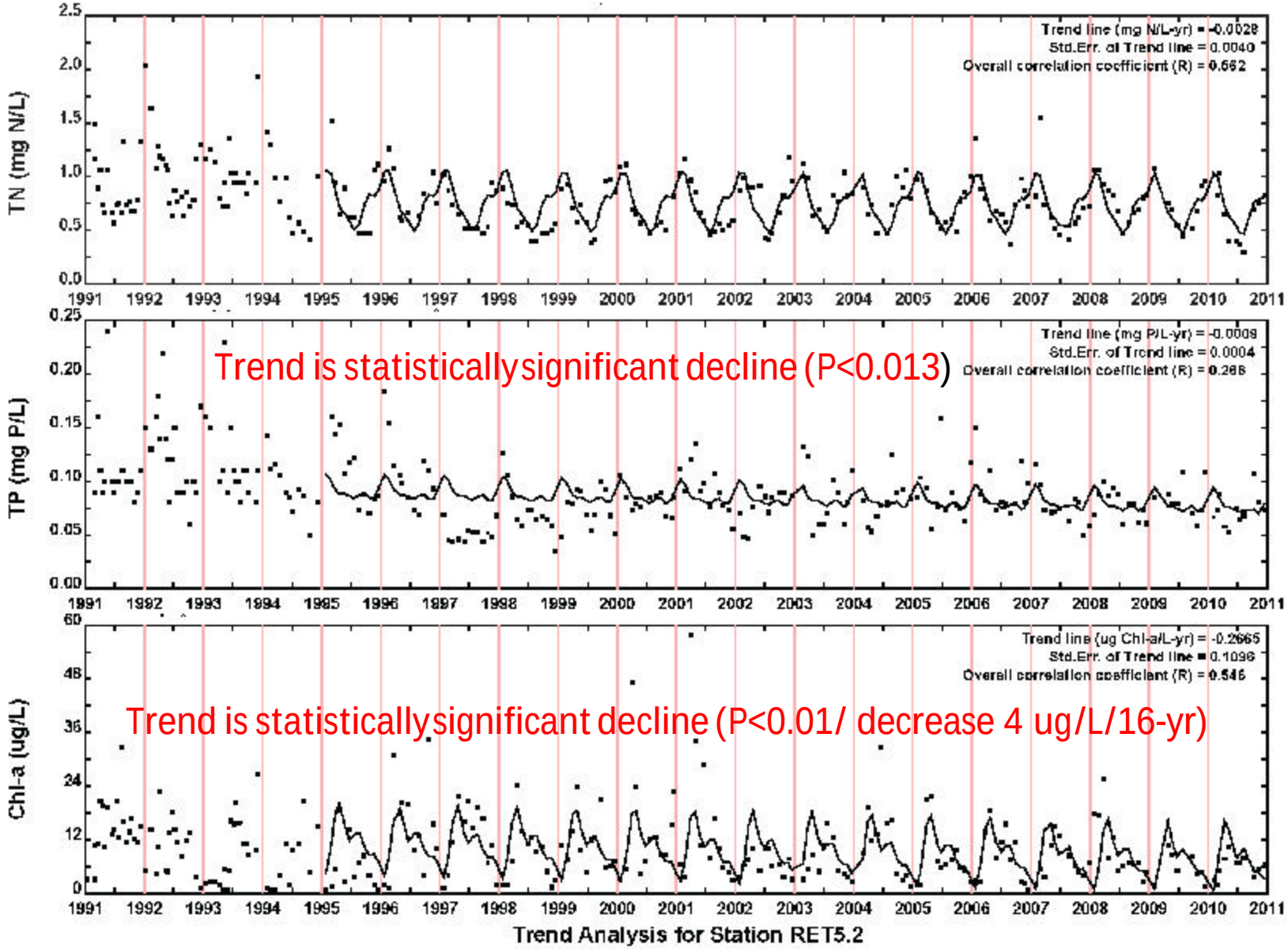
$$?? = ??_{??} + ??_{??}\,??????\,??????? + ??_{??}\,??????\,??????? + ??_{??}\,??????\,??????? + ??_{??}\,??????\,??????? + ??_{??}\,??????(??????) + ??_{??}\,??????\,??????? + ??_{??}?? + ??$$

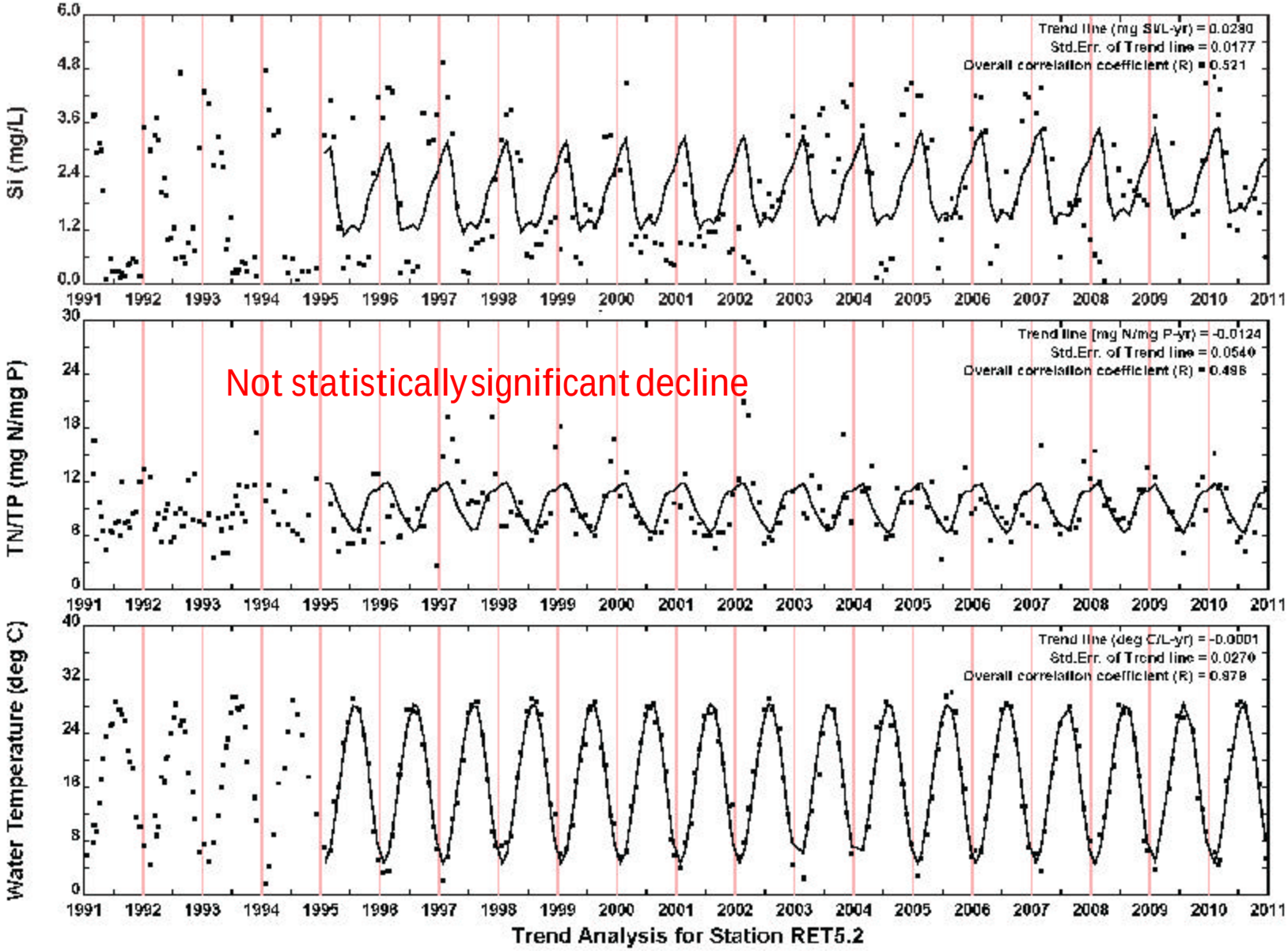
Where

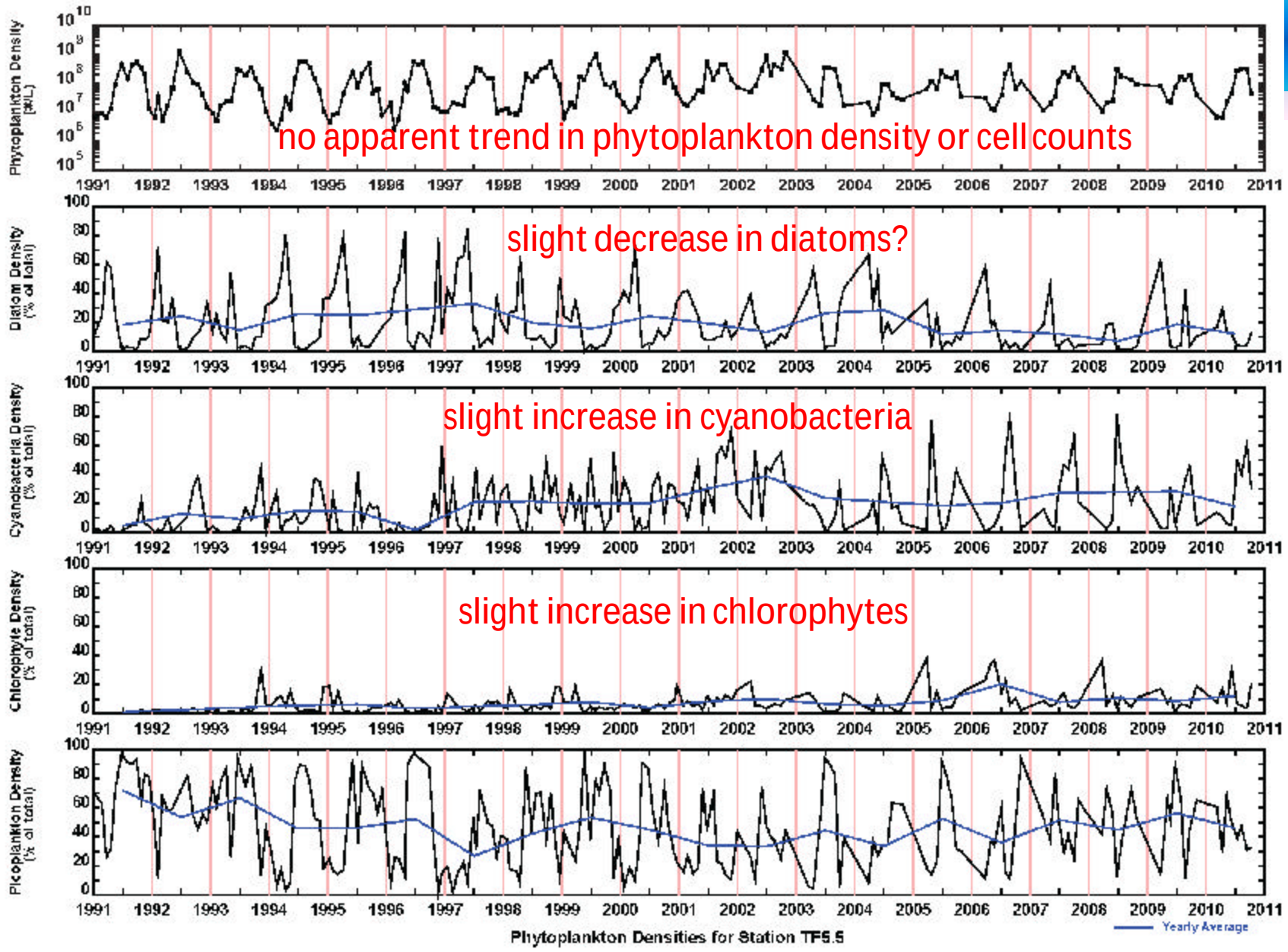
Y	**=**	**dependent water quality variable,**
$ß_n$	**=**	**the regression coefficients,**
T	**=**	**time, and**
e	**=**	**residuals.**


TN (mg N/L)
Trend line (mg N/L-yr) = -0.0036
Std.Err. of Trend line = 0.0041
Overall correlation coefficient (R) = 0.428
Trend is not statistically significant
TP (mg P/L)
Trend line (mg P/L-yr) = -0.0024
Std.Err. of Trend line = 0.0006
Overall correlation coefficient (R) = 0.422
Trend is statistically significant decline (P<0.001)
Chl-a (ug/L)
Trend line (ug Chl-a/L-yr) = -0.1187
Std.Err. of Trend line = 0.2847
Overall correlation coefficient (R) = 0.837
Trend is not statistically significant
Trend Analysis for Station TF5.5

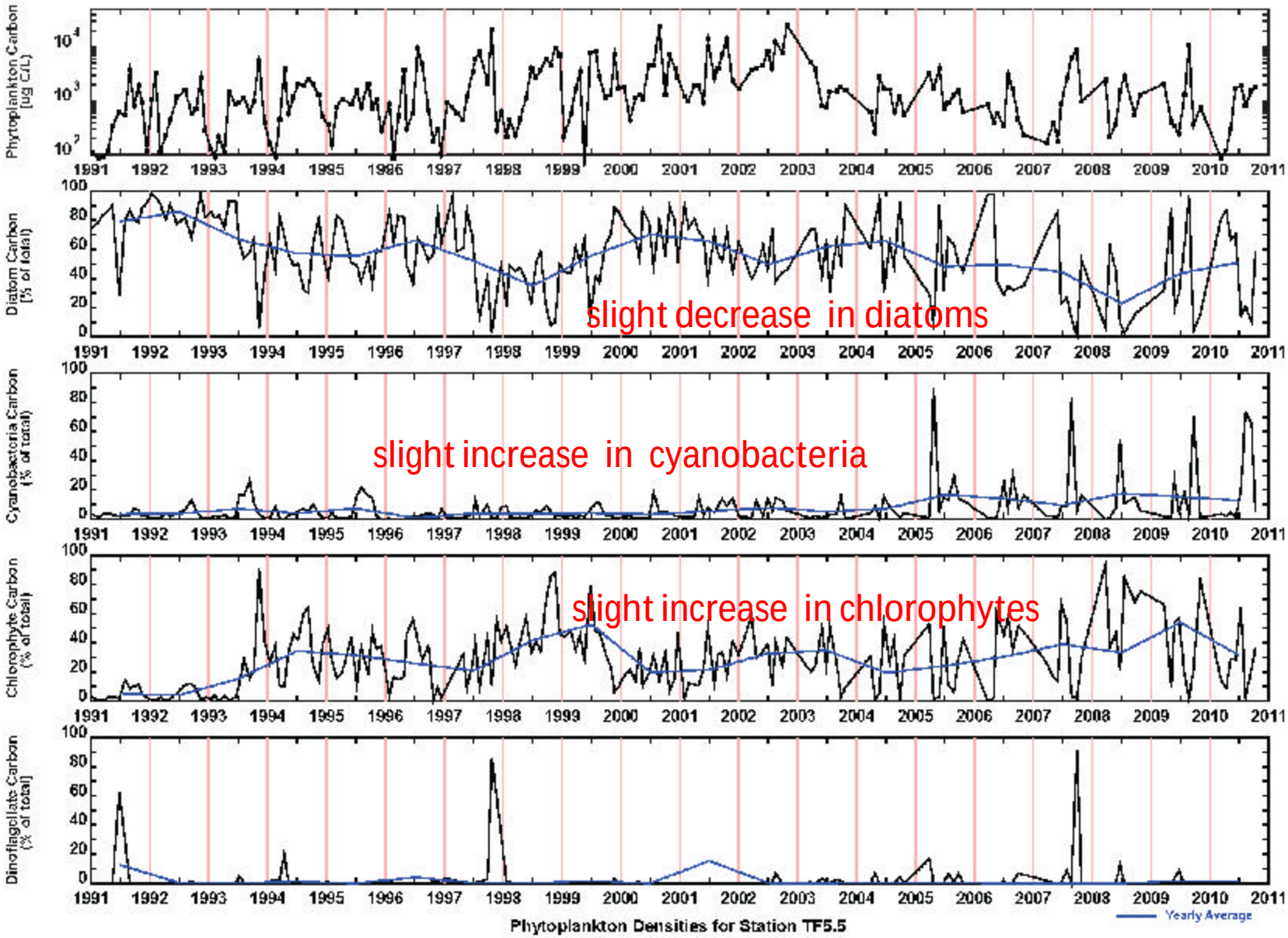

Si (mg/L)
Trend line (mg Si/L-yr) = -0.0280
Std.Err. of Trend line = 0.0242
Overall correlation coefficient (R) = 0.508
TN/TP (mg N/mg P)
Trend line (mg N/mg P-yr) = 0.2380
Std.Err. of Trend line = 0.0601
Overall correlation coefficient (R) = 0.481
Trend is statistically significant
Water Temperature (deg C)
Trend line (deg C/L-yr) = 0.0228
Std.Err. of Trend line = 0.0316
Overall correlation coefficient (R) = 0.974
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Trend Analysis for Station TF5.5


TN (mg N/L)
Trend line (mg N/L-yr) = -0.0028
Std.Err. of Trend line = 0.0040
Overall correlation coefficient (R) = 0.662
TP (mg P/L)
Trend line (mg P/L-yr) = -0.0009
Std.Err. of Trend line = 0.0004
Overall correlation coefficient (R) = 0.266
Trend is statistically significant decline (P<0.013)
Chl-a (ug/L)
Trend line (ug Chl-a/L-yr) = -0.2665
Std.Err. of Trend line = 0.1096
Overall correlation coefficient (R) = 0.546
Trend is statistically significant decline (P<0.01/ decrease 4 ug/L/16-yr)
Trend Analysis for Station RET5.2


Si (mg/L)
Trend line (mg Si/L-yr) = 0.0280
Std.Err. of Trend line = 0.0177
Overall correlation coefficient (R) = 0.521
TN/TP (mg N/mg P)
Trend line (mg N/mg P-yr) = -0.0124
Std.Err. of Trend line = 0.0540
Overall correlation coefficient (R) = 0.498
Not statistically significant decline
Water Temperature (deg C)
Trend line (deg C/L-yr) = -0.0001
Std.Err. of Trend line = 0.0270
Overall correlation coefficient (R) = 0.978
Trend Analysis for Station RET5.2



Courtesy of Howard Marshall and Todd Edgerton


Phytoplankton Carbon [ug C/L]
Diatom Carbon [% of total]
Cyanobacteria Carbon [% of total]
Chlorophyte Carbon [% of total]
Dinoflagellate Carbon [% of total]
slight decrease in diatoms
slight increase in cyanobacteria
slight increase in chlorophytes
Yearly Average
Phytoplankton Densities for Station TF5.5

Correlation Analyses

- The purpose was to determine if the observed data would lend themselves to predicting chlorophyll biomass using an empirical modeling approach
- Using “raw data” from 1995-2010
- Using “binned” or monthly averaged data from 1995-2010

Phytoplankton vs TN

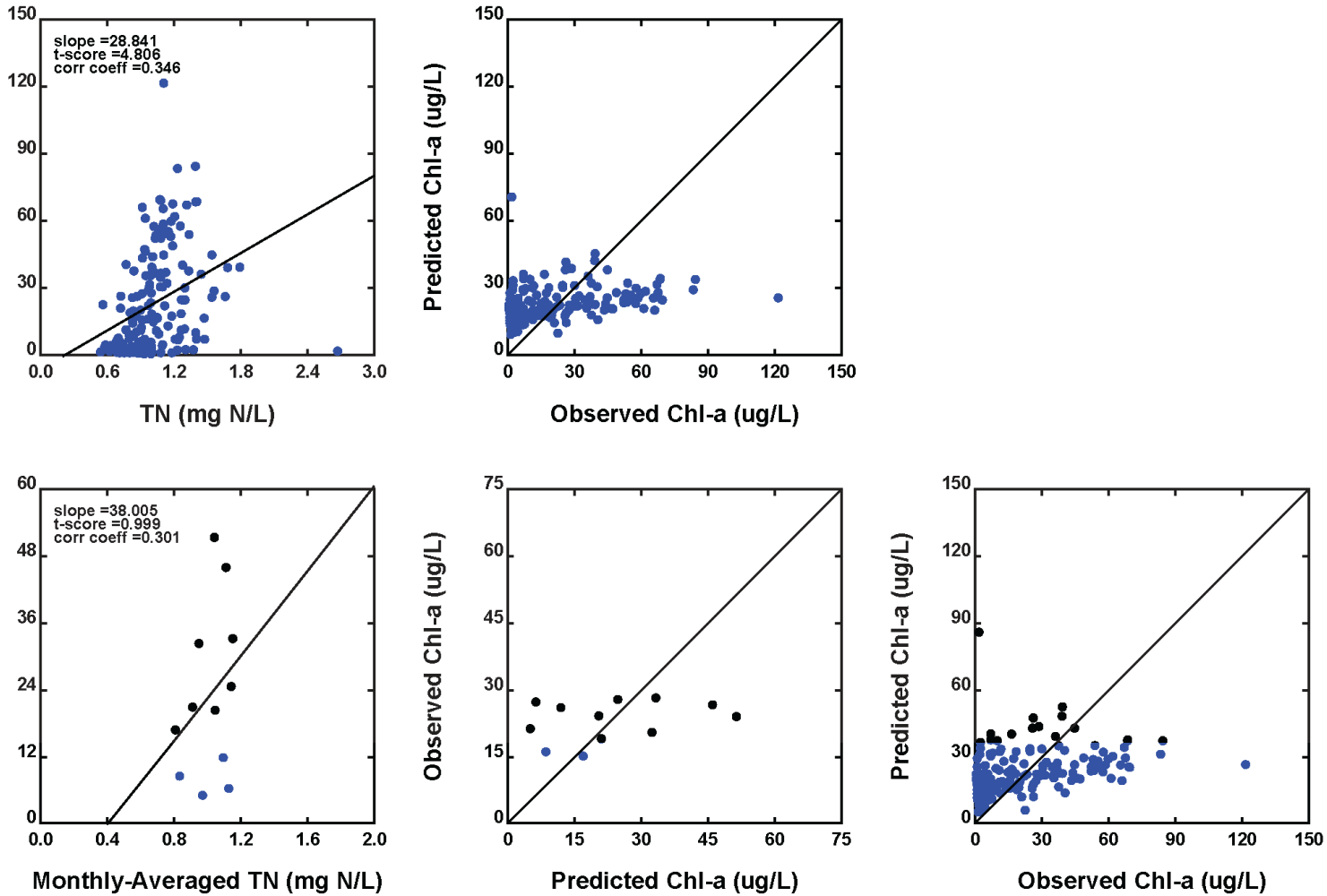


Figure 42. Regression Analysis Results for Chlorophyll-a versus TN for Station TF5.5

Phytoplankton vs TN

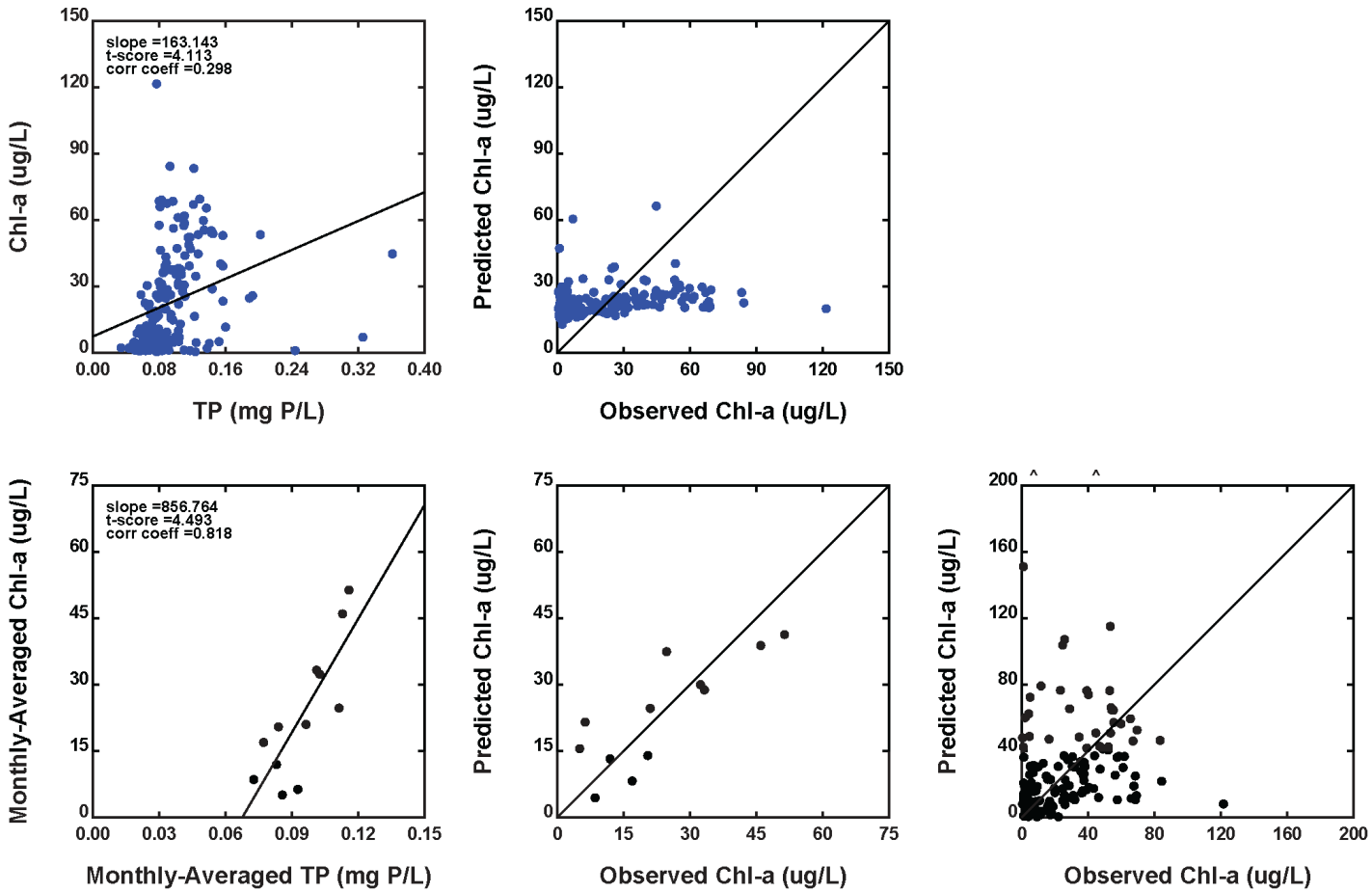


Figure 43. Regression Analysis Results for Chlorophyll-a versus TP for Station TF5.5

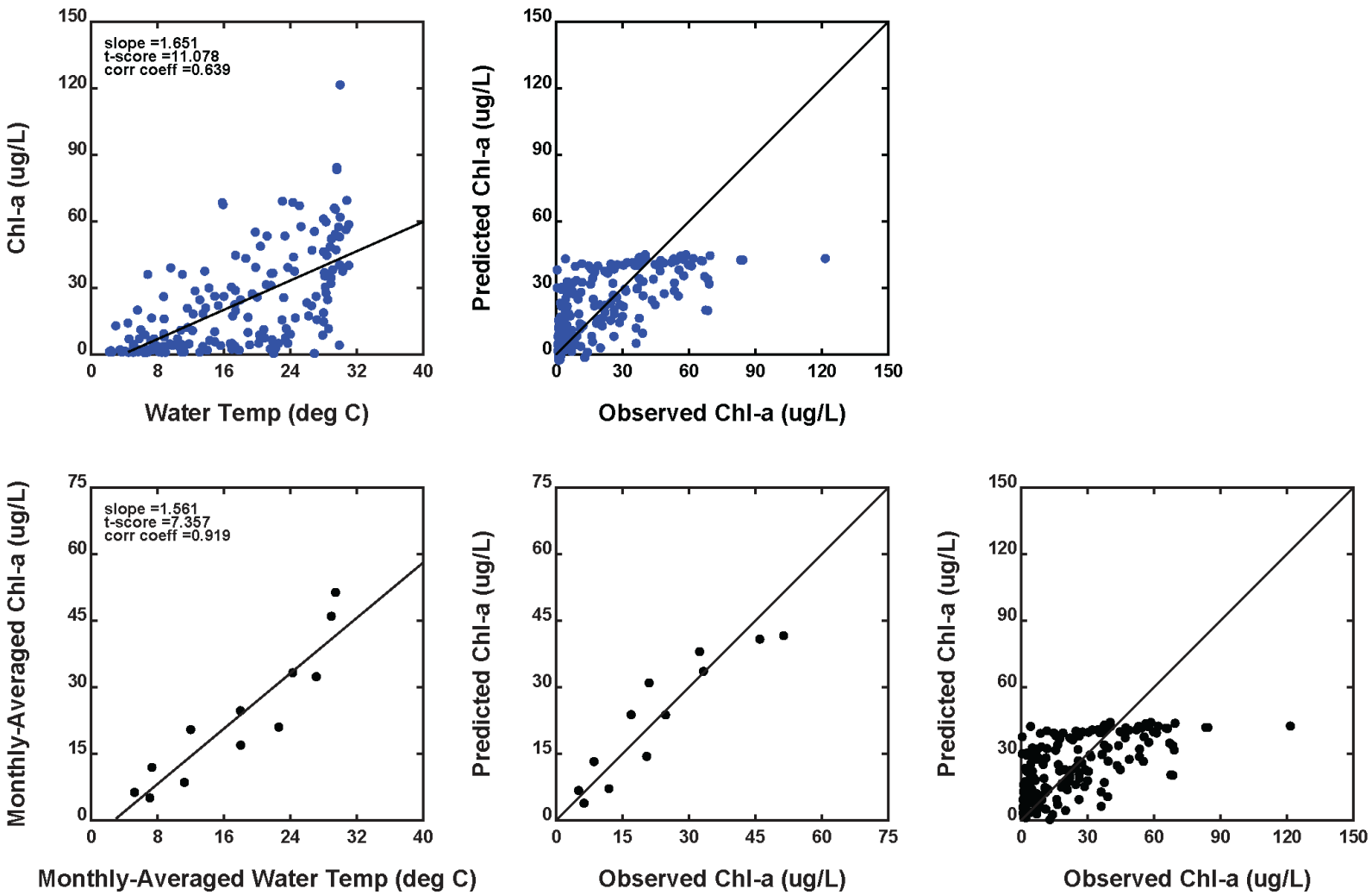


Figure 44. Regression Analysis Results for Chlorophyll-a versus Water Temperature (WTEMP) for Station TF5.5

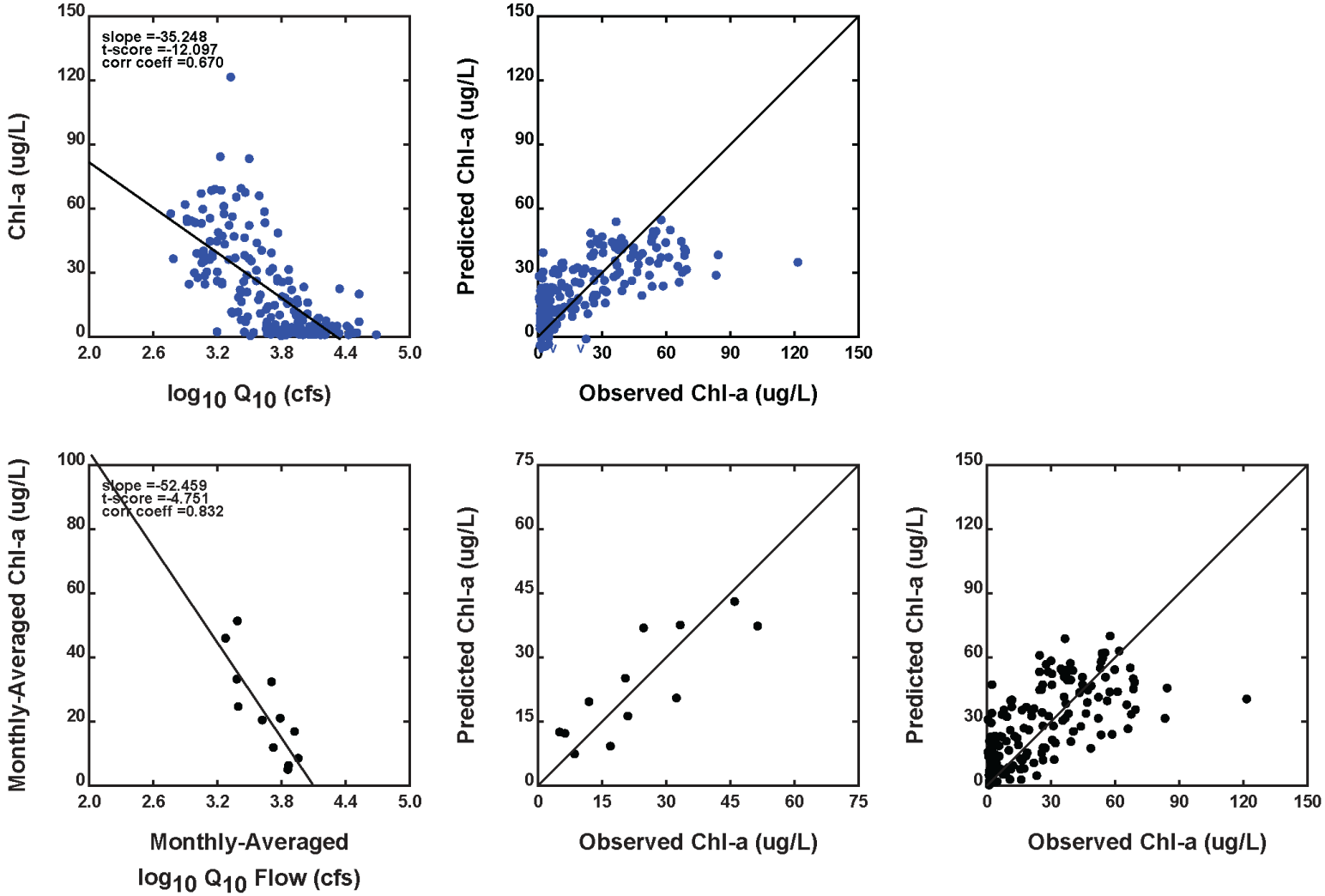


Figure 45. Regression Analysis Results for Chlorophyll-a versus Log10 Transformed 10-day Averaged Freshwater Flow (Q10) for Station TF5.5

Multiple linear regression (Phytoplankton vs temp., Q, TN, TP)

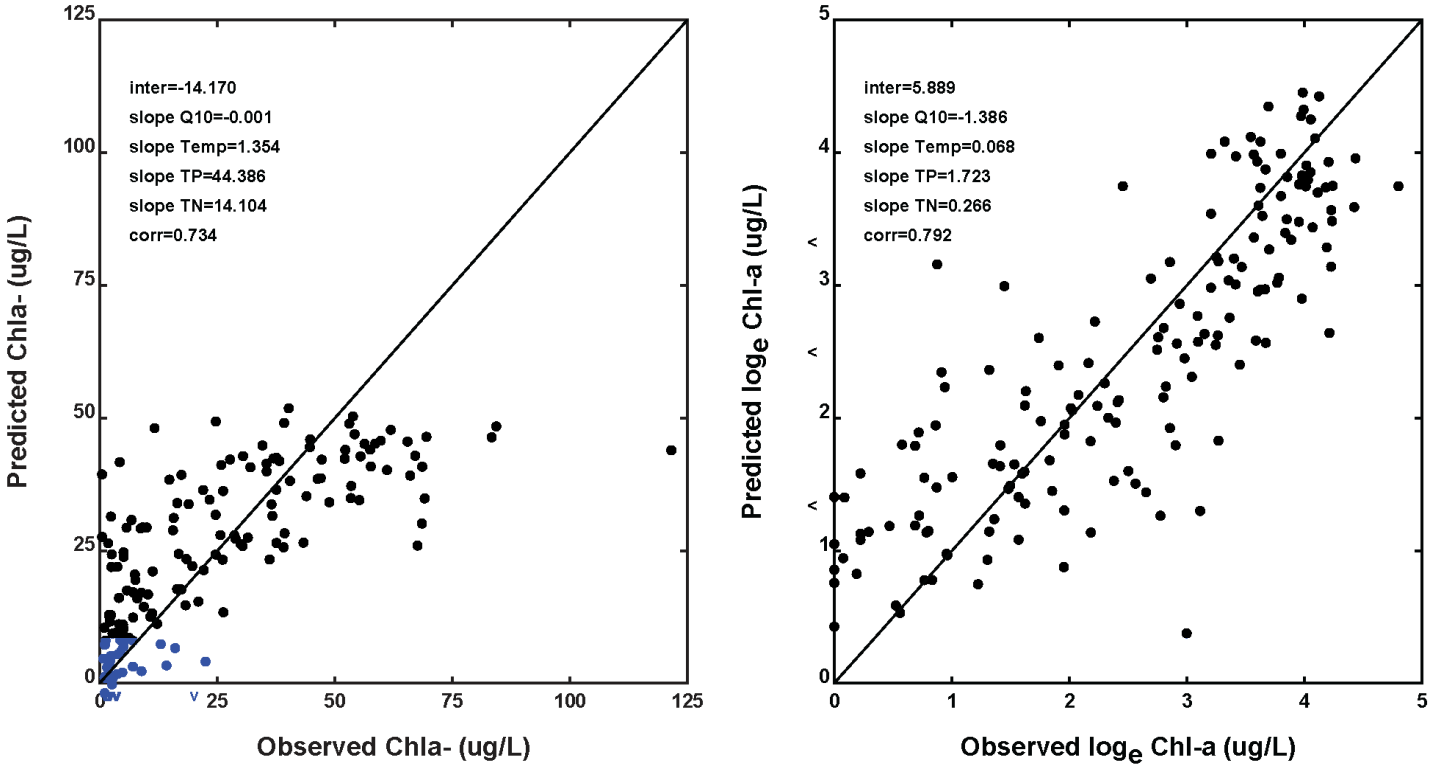


Figure 46. Multiple Linear Regression Analysis Results for Chlorophyll-a versus TN, TP, WTEMP, and Q10 for Station TF5.5 – Raw Data

Multiple linear regression

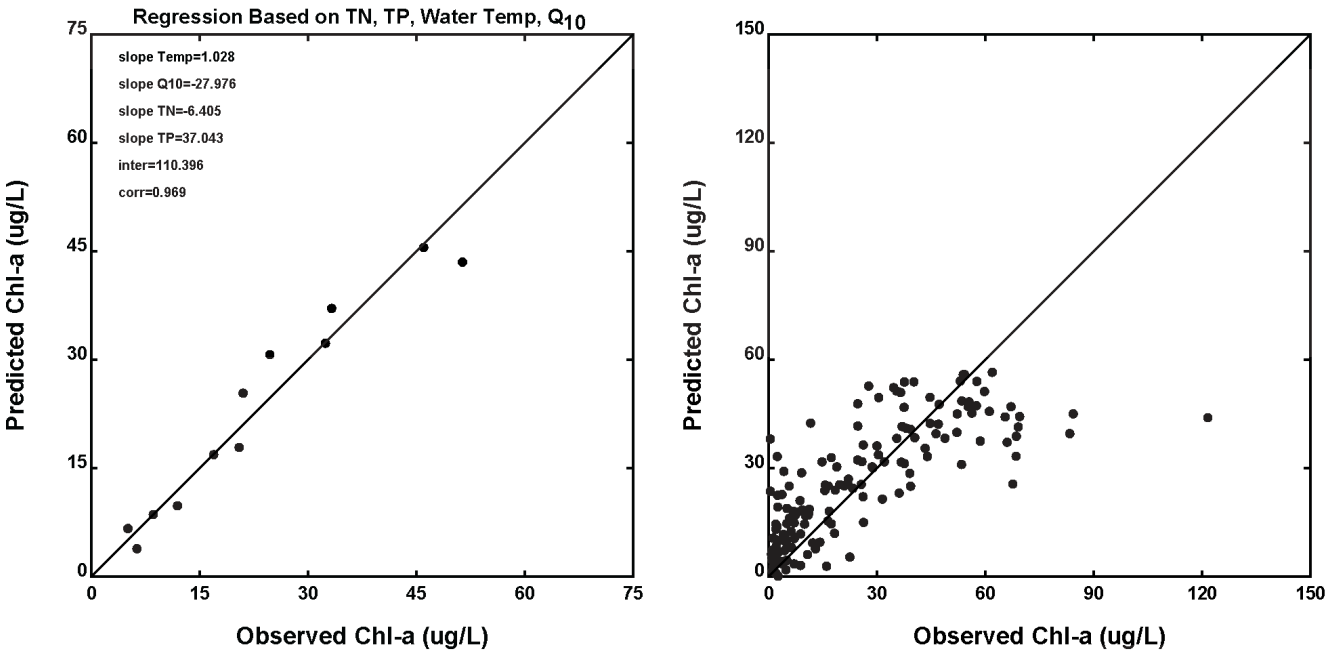


Figure 47. Multiple Linear Regression Analysis Results for Chlorophyll-a versus TN, TP, WTEMP, and Q10 for Station TF5.5 – Monthly-Averaged Data

Summary

- Loading of TP decrease above fall line was statistically significant, which results in an increase of TN:TP.
- There were no significant trends in TN concentration. TP concentrations declined significantly in the tidal fresh, mesohaline, and polyhaline regions of the river.
- Chlorophyll declined in the mesohaline.
- Regression models performed poorly in predicting the raw chlorophyll data
- The construction of an empirically based model to predict chlorophyll concentrations in the tidal James River is not feasible.