Benthic Algal Accumulation During 16 Day Colonization Period In Different Nutrient Regimes

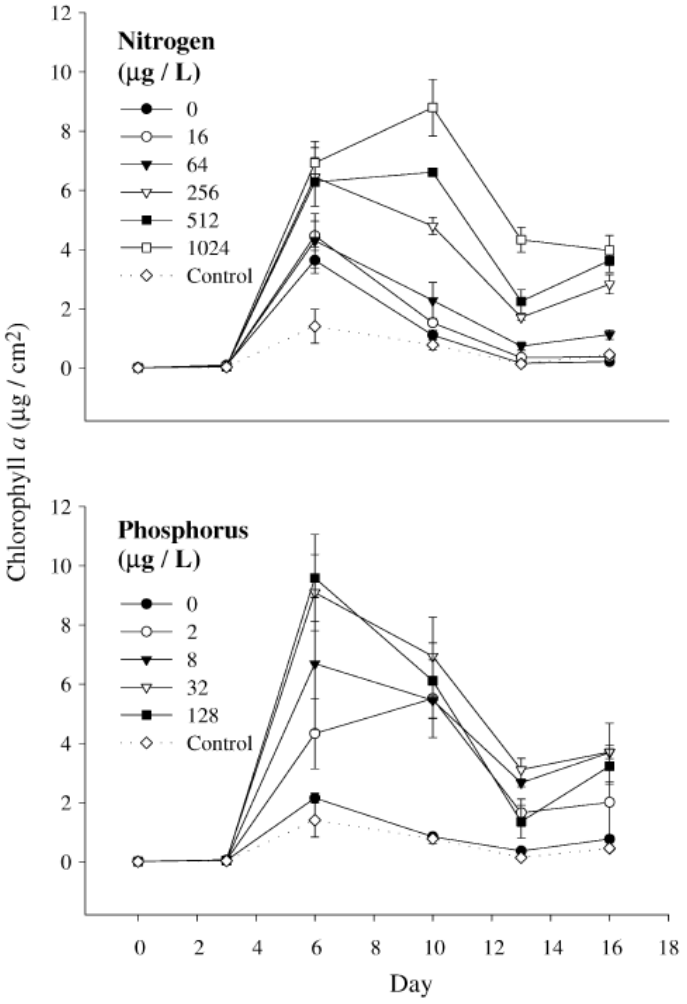


Figure 1. Benthic algal accumulation patterns on clay tiles in recirculating streams with 25 cm/s current (Stevenson and Rier 2006). Algae were grown in different N concentrations with growth-saturating P supply and in different P concentrations with growth-saturating N supply. Nutrient concentrations were manipulated by adding $NaNO_3$ or KH_2PO_4 to reach treatment concentrations. Biomass accumulation patterns over a 16 day period show rapid accumulation during the first week of colonization and then loss of algae. Growth rates were calculated with accumulation from days 3-6. Peak biomass was the maximum biomass reached during the growth period and calculated as the highest average of biomasses for two successive sampling periods.

Benthic Algal Growth Rate & Peak Biomass Response to N and P Concentration

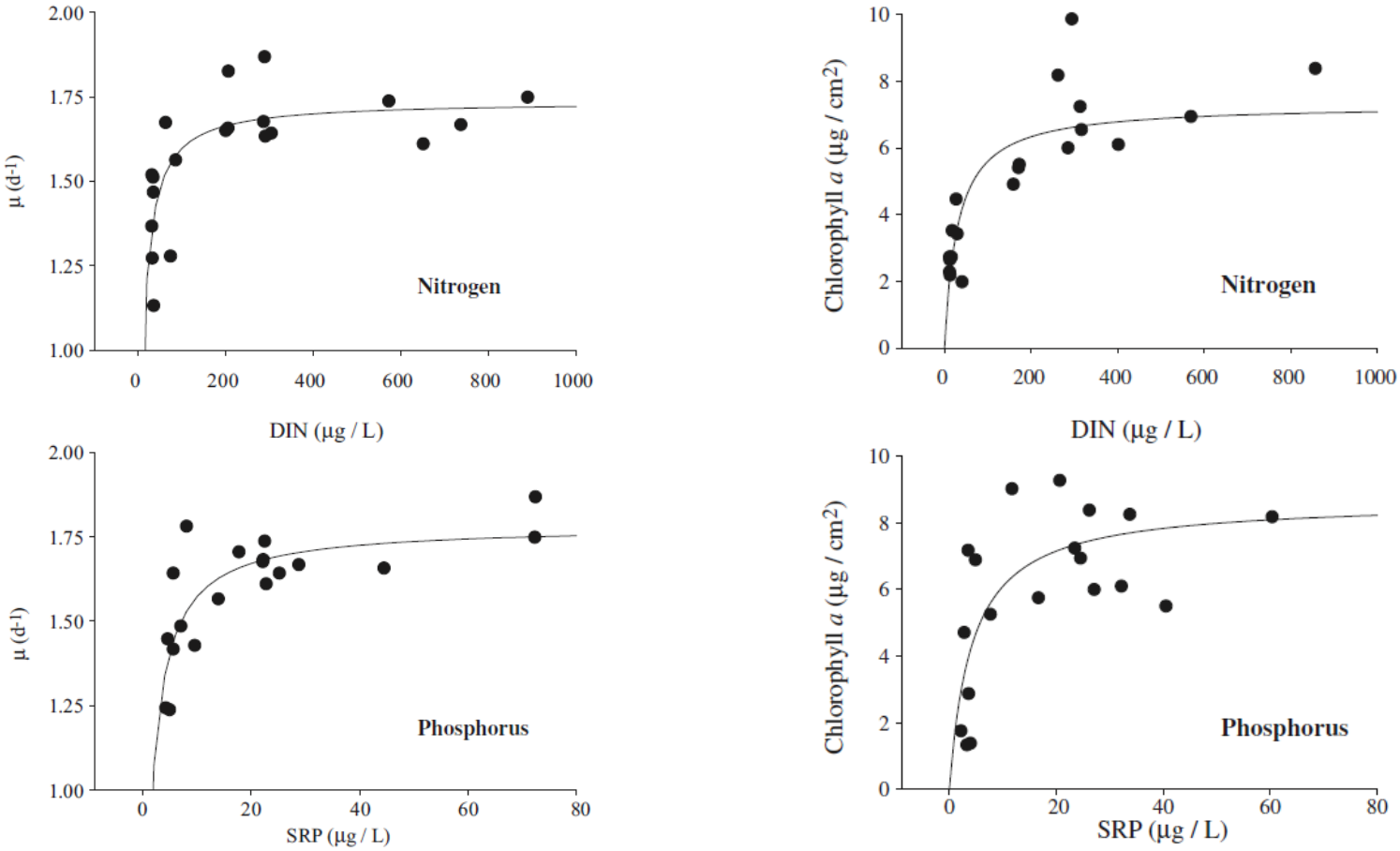


Figure 2. Benthic algal growth rates (μ) and peak biomass (chlorophyll a) on clay tiles in recirculating streams with 25 cm/s current (Stevenson and Rier 2006). See Fig. 1 for details. Growth rates and peak biomass respond asymptotically to nitrogen and phosphorus concentrations with growth rate saturation (90% of maximum) at 86 μg DIN/L and 8 μg SRP/L. Peak biomass reached 90% of maxima at 306 μg DIN/L and 38 μg SRP/L.

Filtered & Unfiltered Groundwater & Surface Water

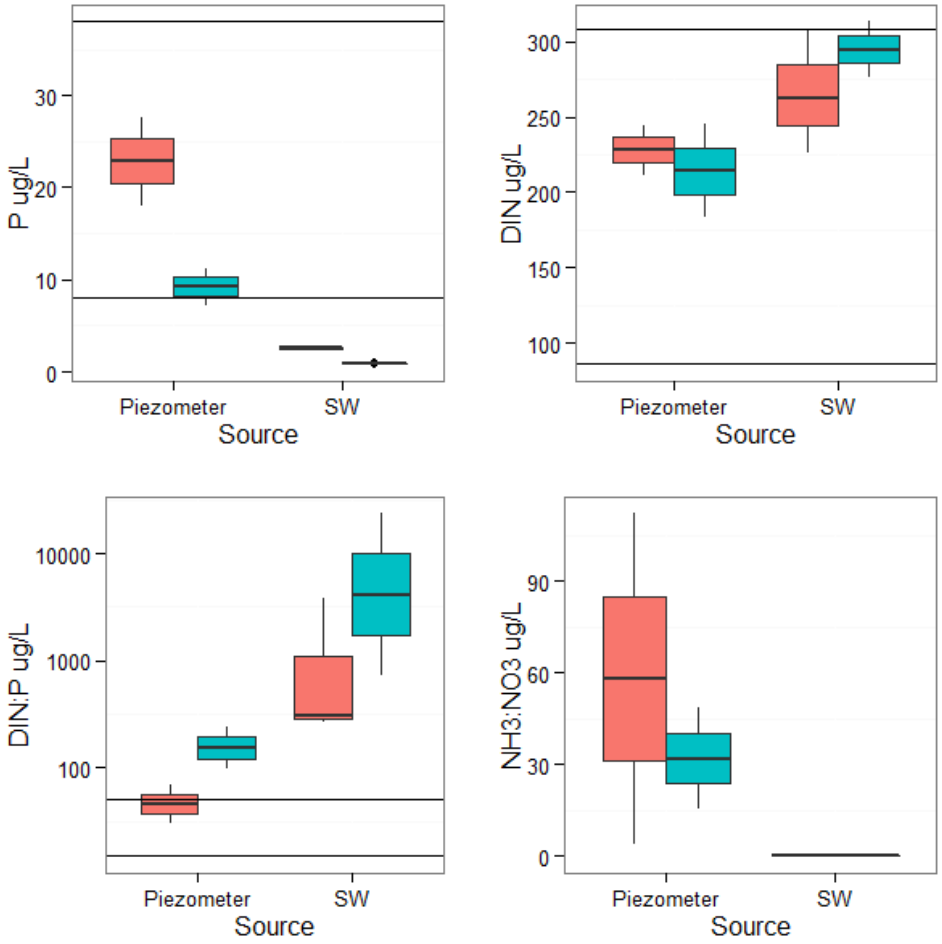


Figure 3. Average of filtered (blue) and unfiltered (red) groundwater by piezometer and surface water samples for Torch Lake for all sites and dates during summer 2015. The horizontal lines indicate nutrient limitation guidelines.

Unfiltered Surfacewater Total Phosphorus

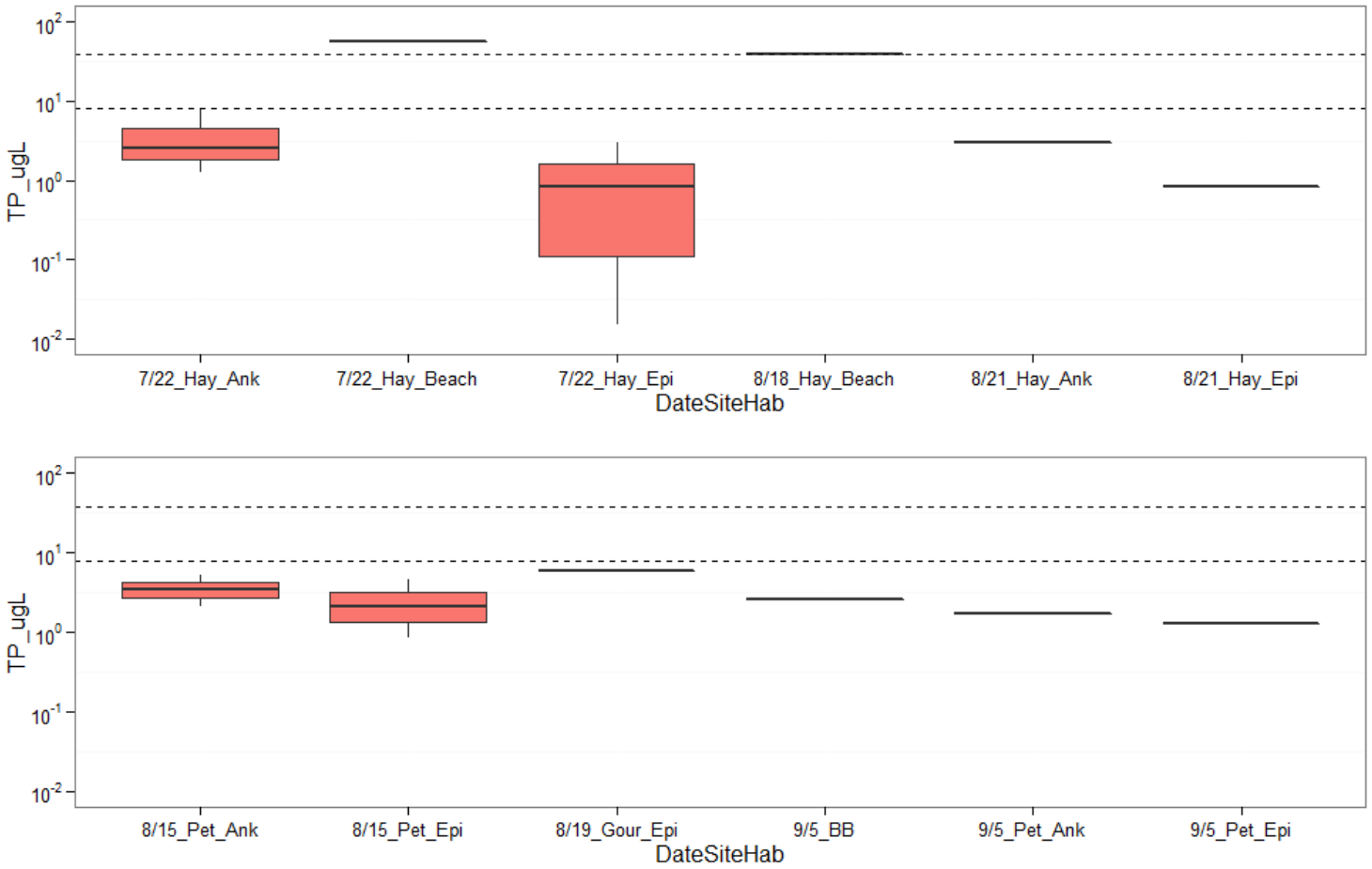


Figure 5. Total phosphorus (TP) concentrations of surface water from unfiltered samples during summer 2015. The horizontal lines indicate nutrient limitation guidelines.

Unfiltered Surfacewater Dissolved Inorganic N

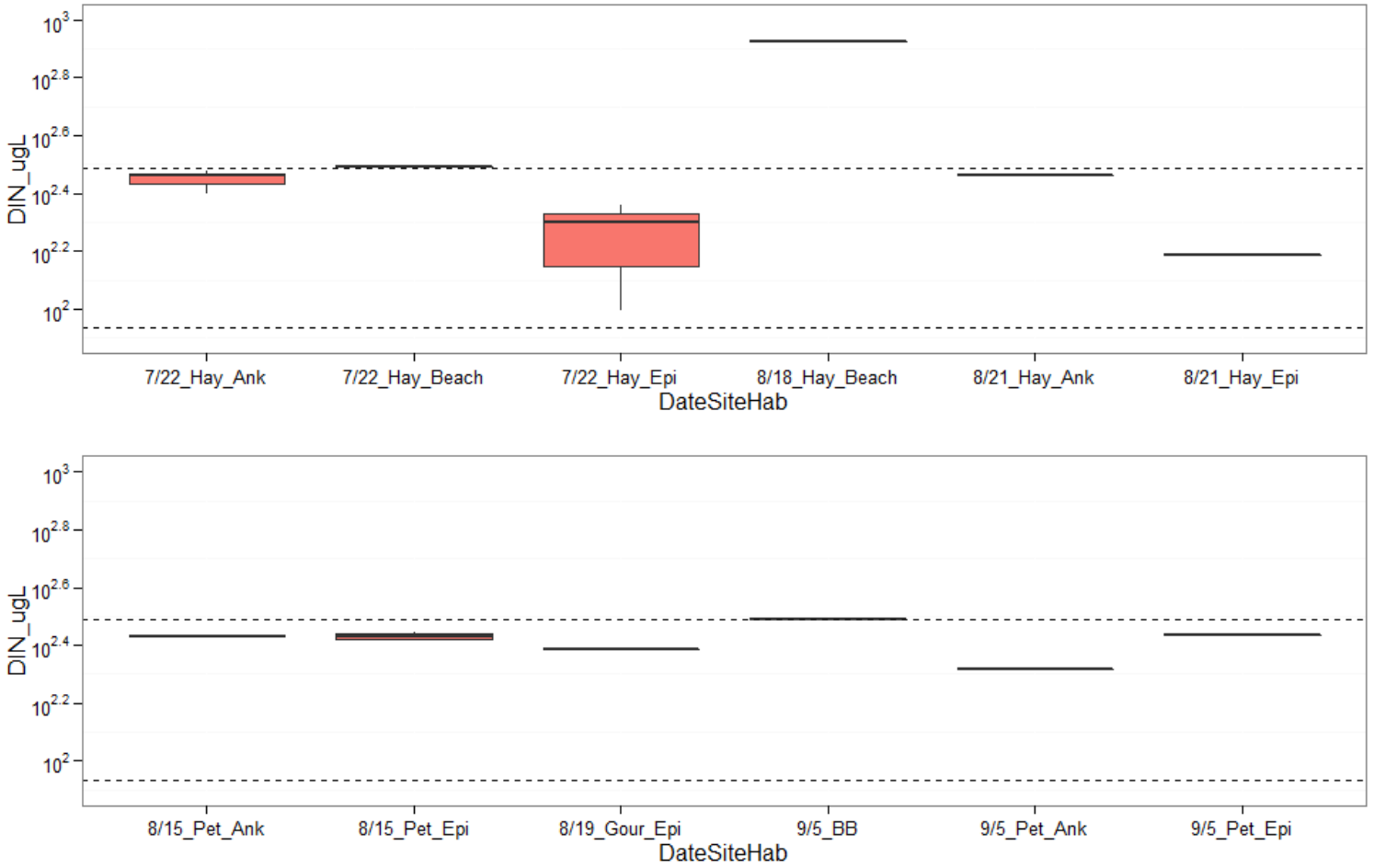


Figure 5. Dissolved inorganic nitrogen (DIN) concentrations of surface water from unfiltered samples during summer 2015. The horizontal lines indicate nutrient limitation guidelines.

Unfiltered Surfacewater DN:TP molar ratio

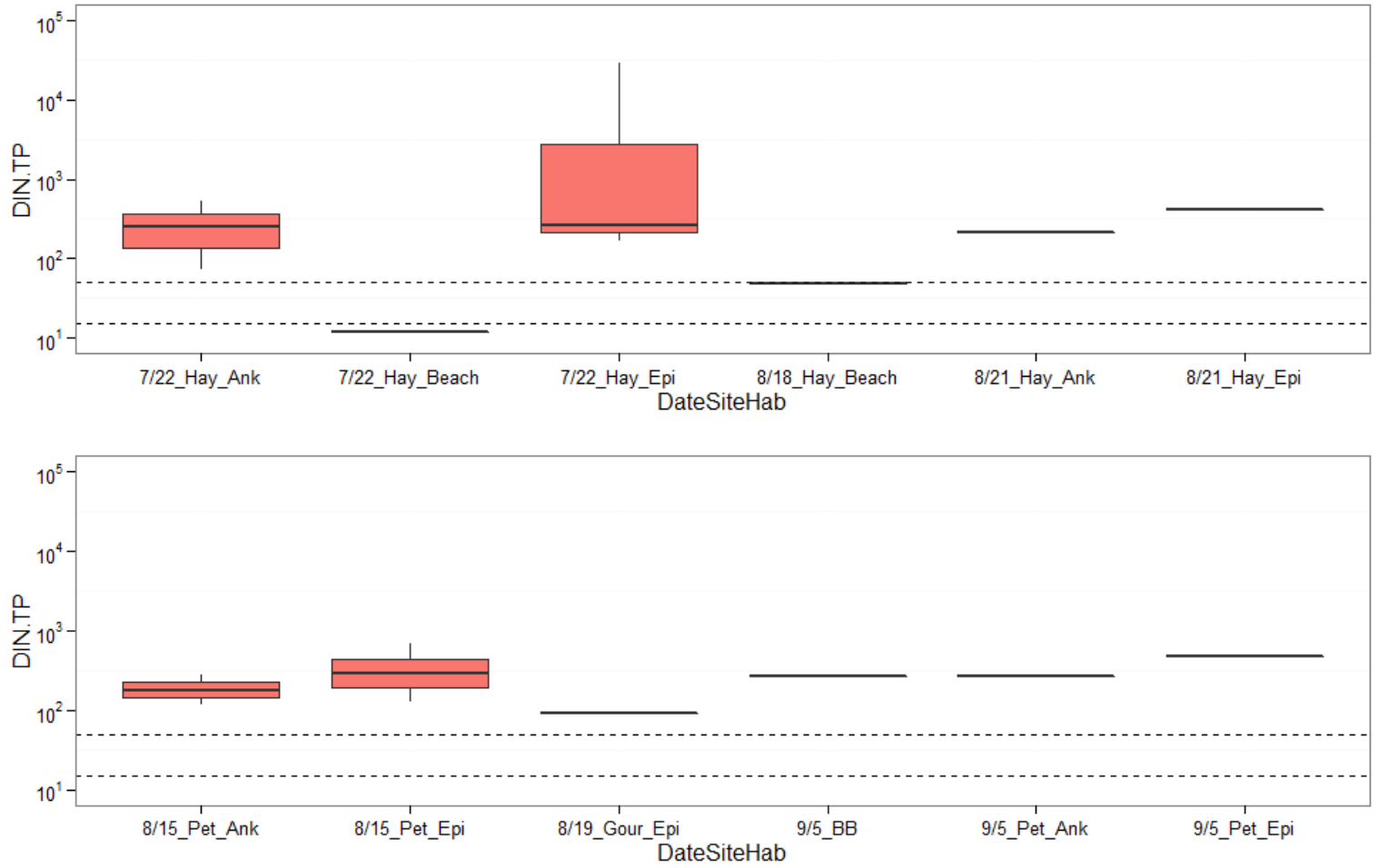


Figure 6. N:P ratios of surface water chemistry from unfiltered samples during summer 2015. The horizontal lines indicate nutrient limitation guidelines.

Unfiltered Surfacewater NH3/NO3 ratio

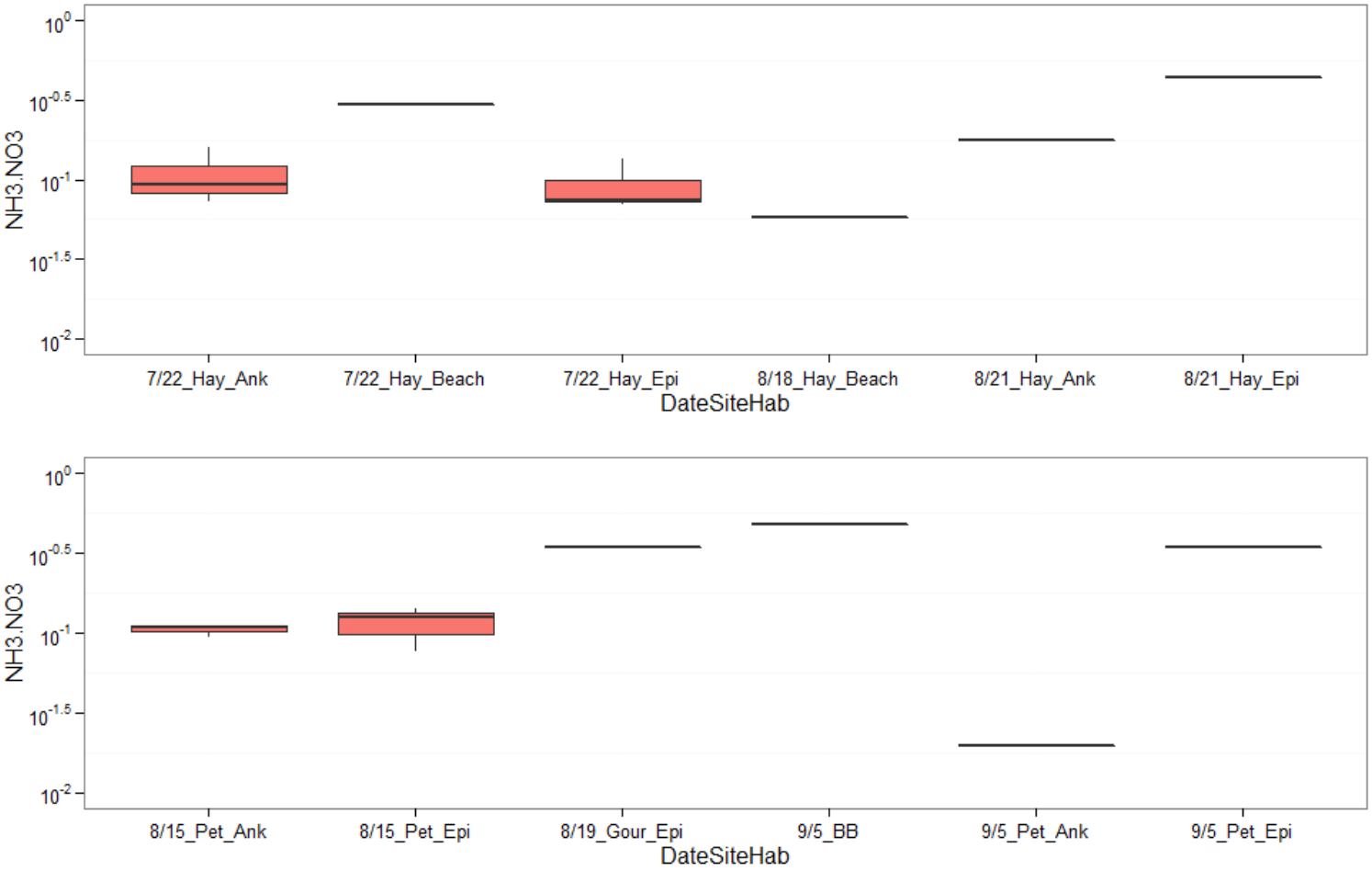


Figure 7. NH_3:NO_3 ratios of surface water chemistry from unfiltered samples during summer 2015.

Filtered Groundwater

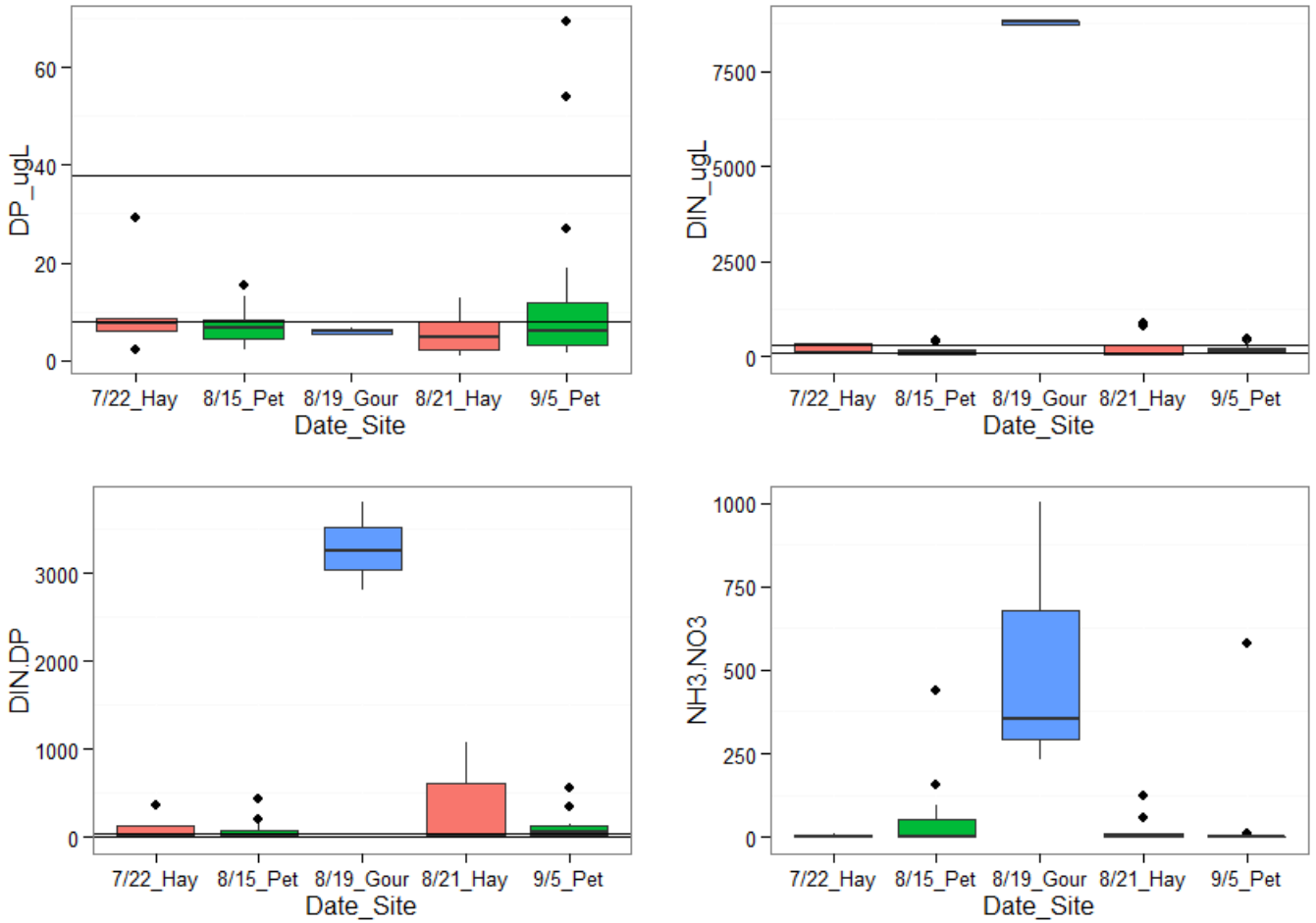


Figure 8. Nutrient concentrations and ratios of groundwater chemistry from filtered samples during summer 2015. The horizontal lines indicate nutrient limitation guidelines. The Gourley location is plotted.

Filtered Groundwater without Gourley

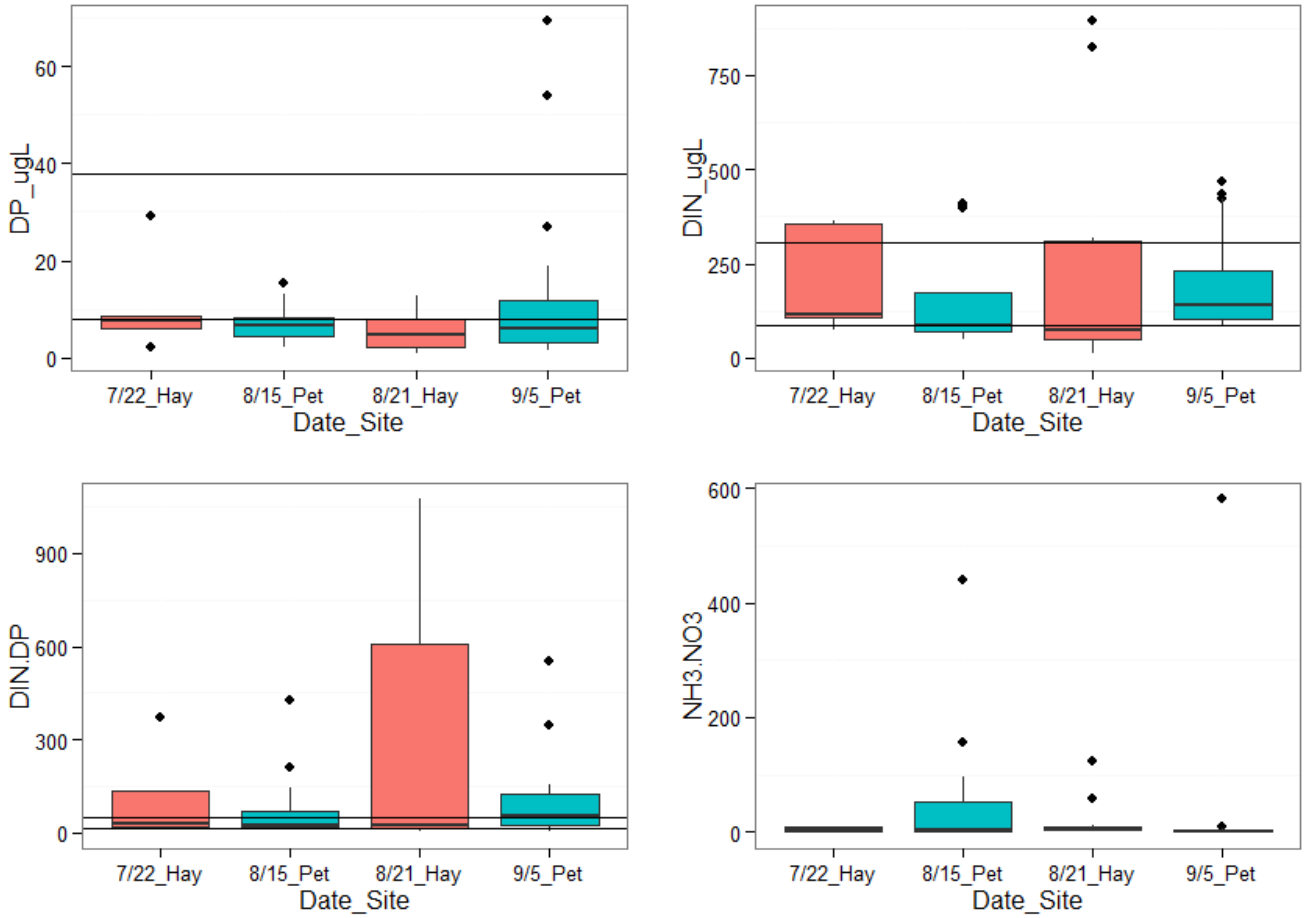


Figure 9. Nutrient concentrations and ratios of groundwater chemistry from filtered samples during summer 2015. The horizontal lines indicate nutrient limitation guidelines. The Gourley location is not plotted.

Unfiltered Groundwater

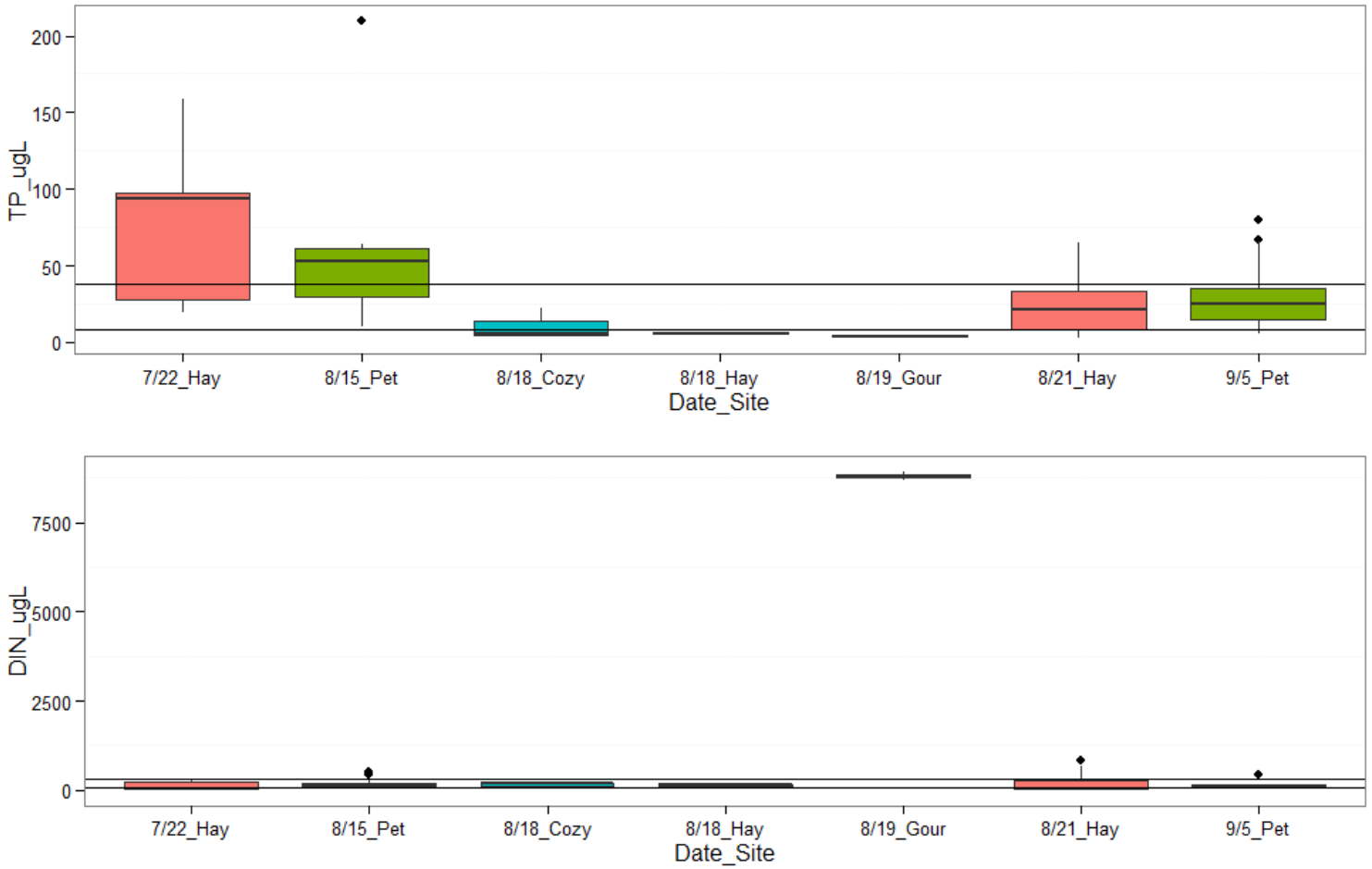


Figure 10. Nutrient concentrations of groundwater chemistry from unfiltered samples during summer 2015. The horizontal lines indicate nutrient limitation guidelines.

Unfiltered Groundwater

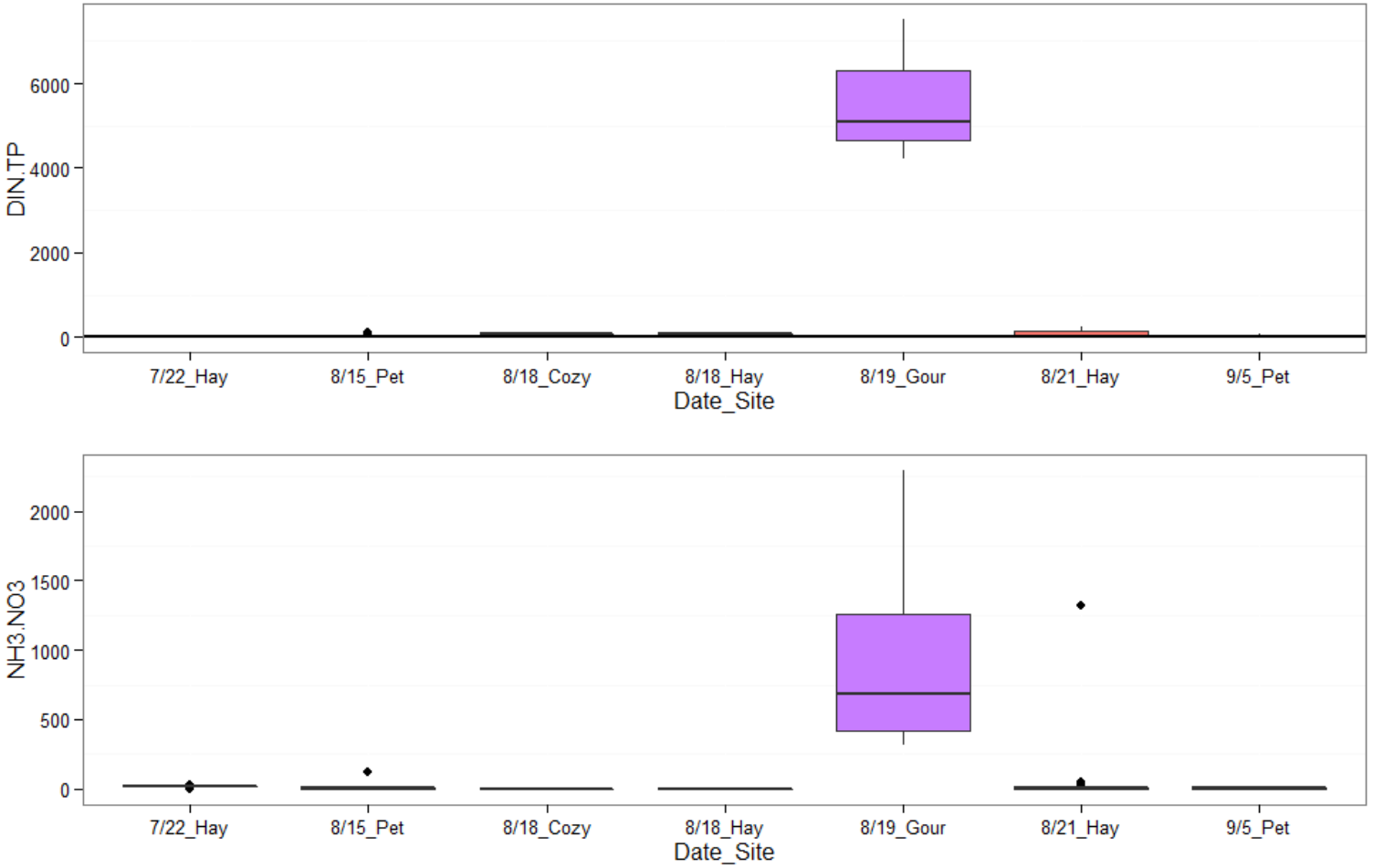


Figure 11. Nutrient ratios of groundwater chemistry from unfiltered samples during summer 2015. The horizontal lines indicate nutrient limitation guidelines.

Unfiltered Groundwater without Gourley

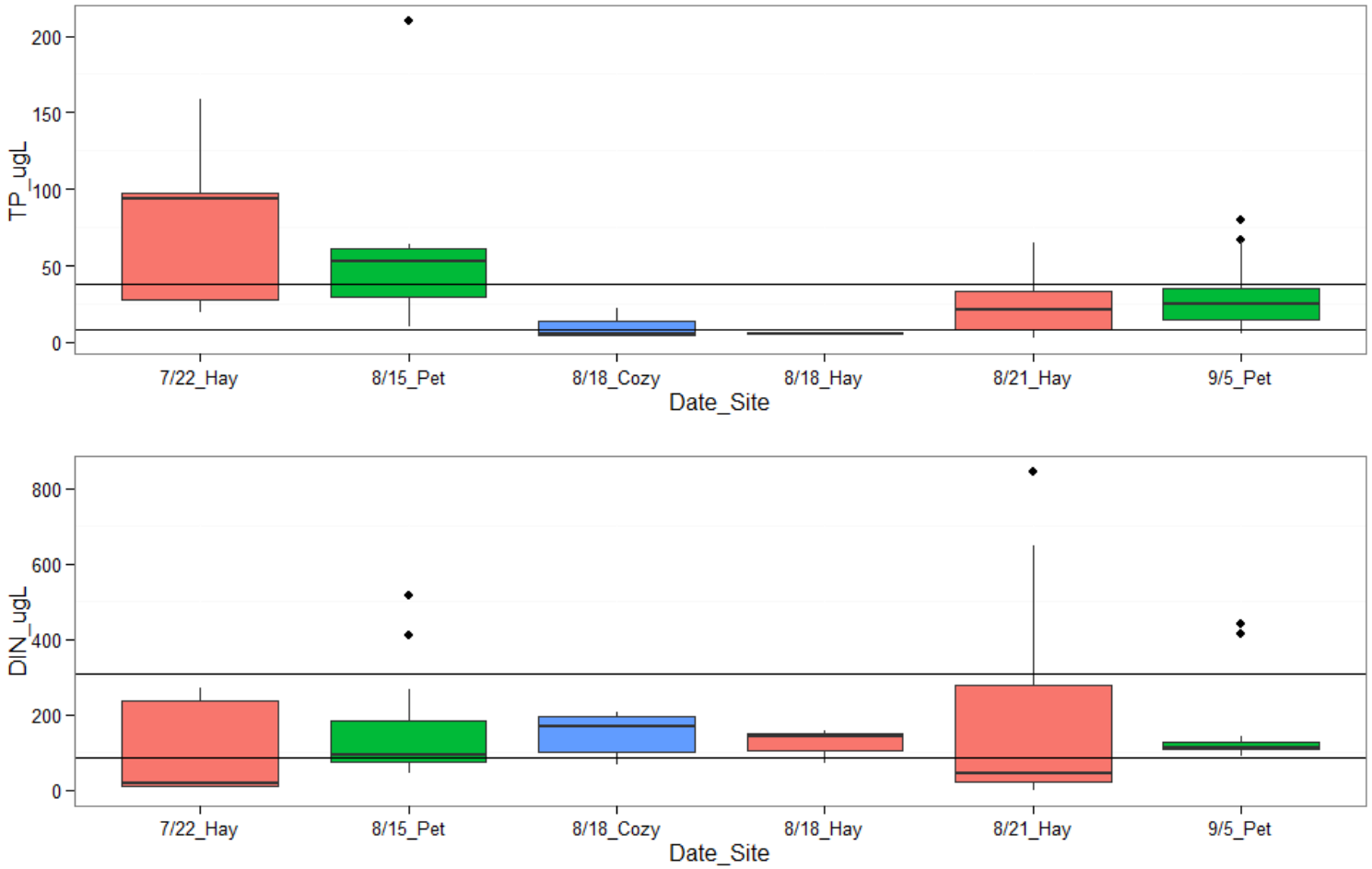


Figure 12. Nutrient concentrations of groundwater chemistry from unfiltered samples. The horizontal lines indicate nutrient limitation guidelines.

Unfiltered Groundwater without Gourley

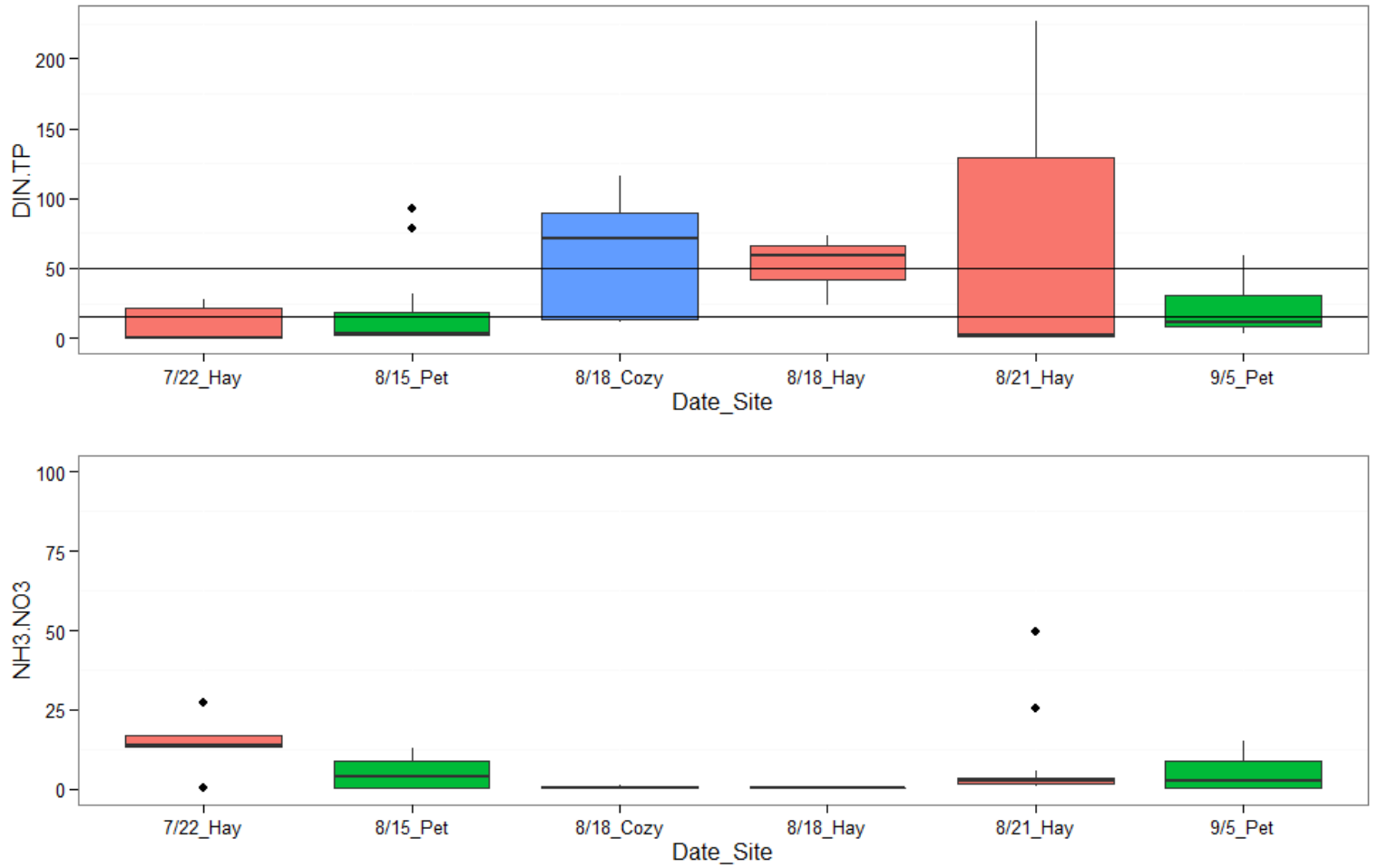


Figure 13. Nutrient ratios of groundwater chemistry from unfiltered samples without the Gourley location plotted. The horizontal lines indicate nutrient limitation guidelines.

Algal Cell Density (Cells/cm^2) by Habitat

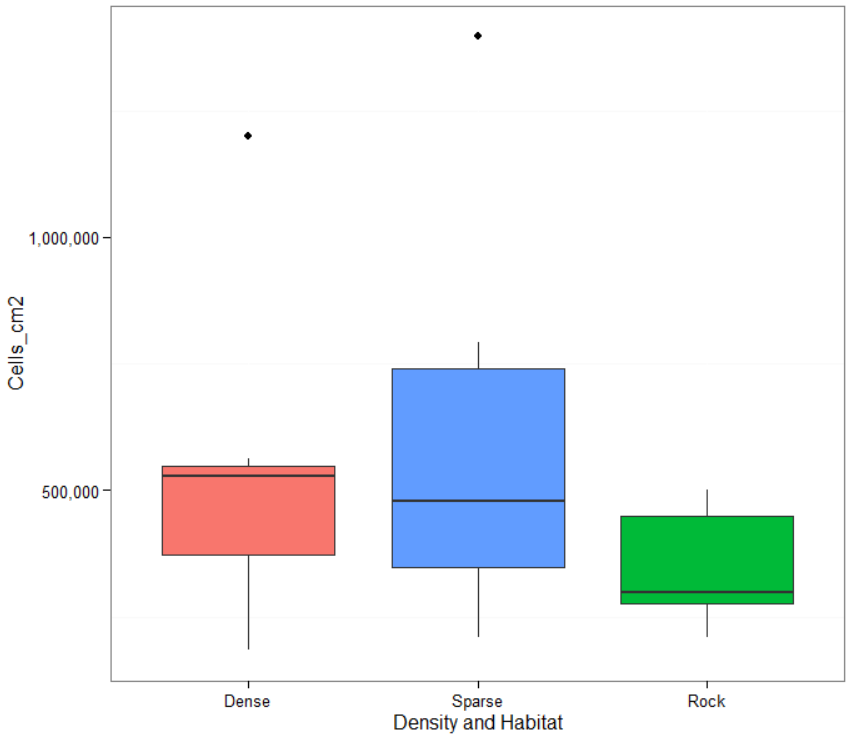


Figure 14. Benthic algal cell density (cells/cm^2) in dense sand (Dense), sparse sand (Sparse), and rock habitats.

Algal Cell Density Not Related to Depth

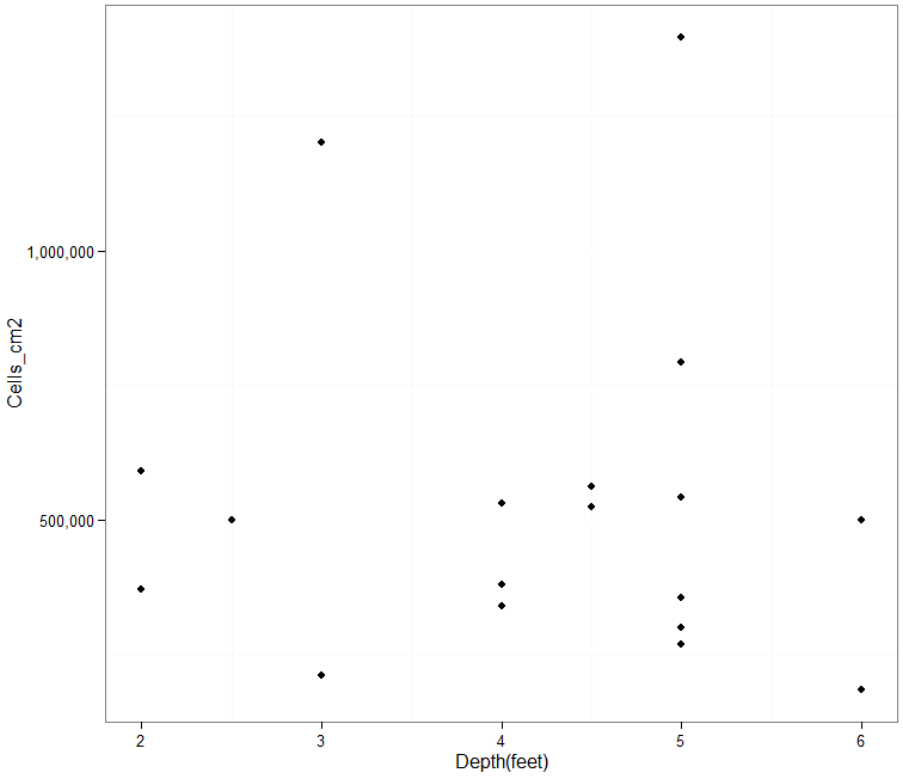


Figure 15. Relationship between benthic algal cell density on sand and water depth as an indicator of distance from shore and source of pollution.

All Benthic Diatom Samples in Ordination

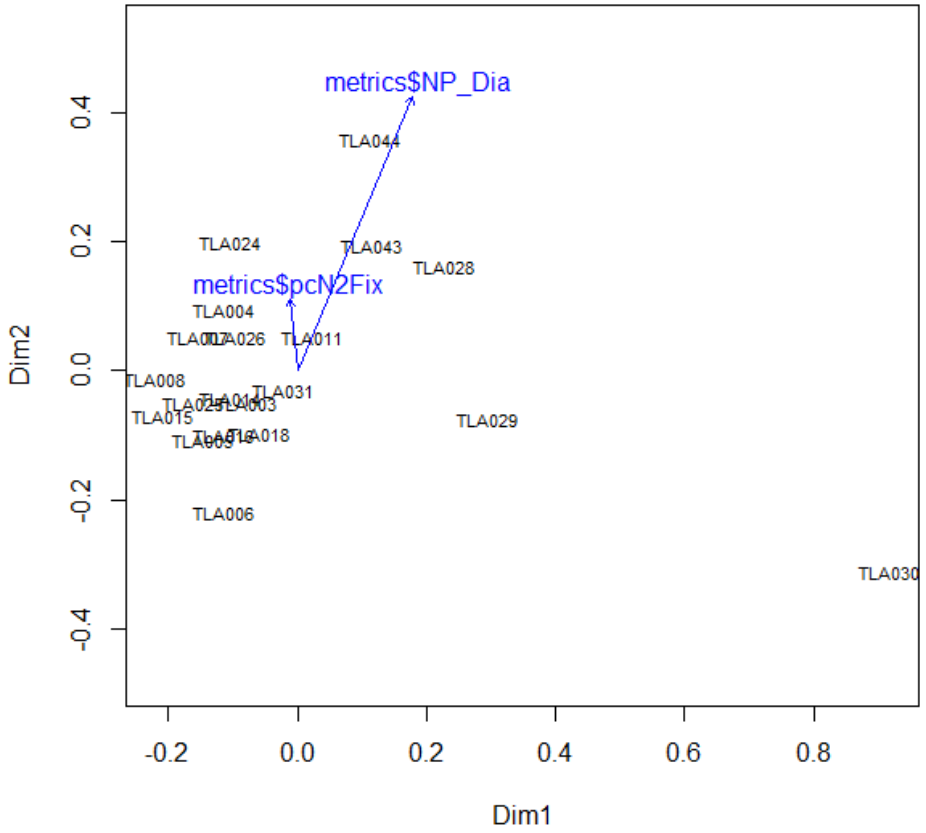


Figure 16. NMDS ordination mapping samples in species space. Distances between samples indicate similarity in species composition. The blue arrows indicate the relationship of changes in species composition and diatom metrics of environmental conditions (NP_Dia = N & P concentrations; pcN2Fix = percent diatoms with nitrogen fixing endosymbionts).

17 Most Similar Torch Lake Benthic Diatom Samples

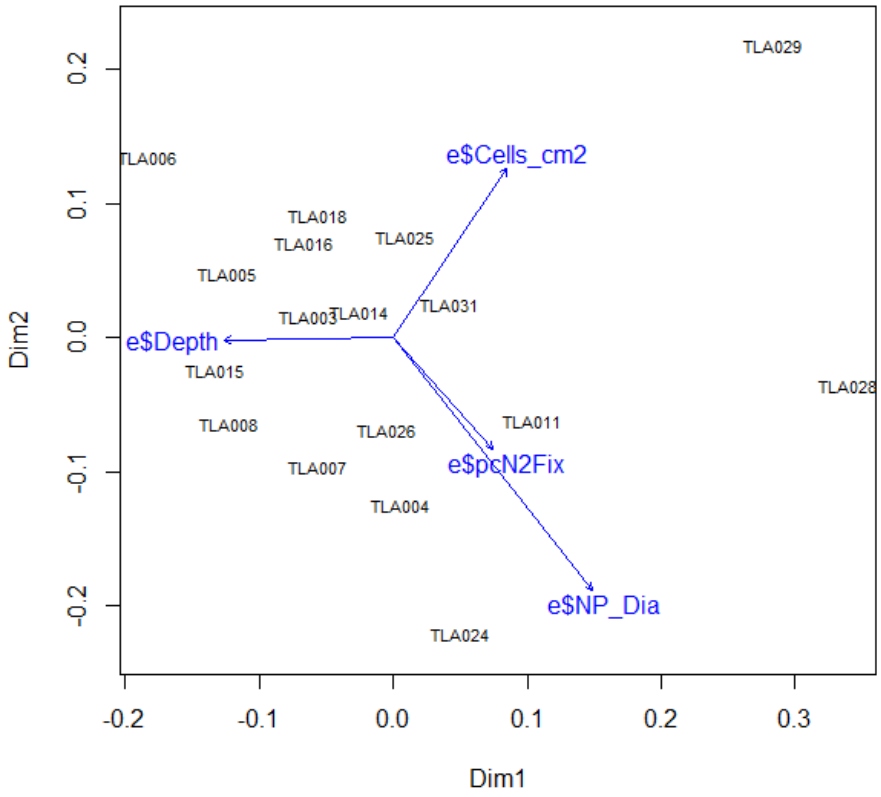


Figure 17. NMDS ordination mapping 17 most similar samples in species space (dropping Becky's Beach, Lake Bellaire, and Elk Lake samples from Figure 16). See Figure 16 for details. (Cells_cm2 = cells per cm^2 of benthic algae in samples; Depth = water depth of samples).

Distinction Among Rock, Dense Sand, and Sparse Sand Habitats for 17 Most Similar Torch Lake Diatom Samples

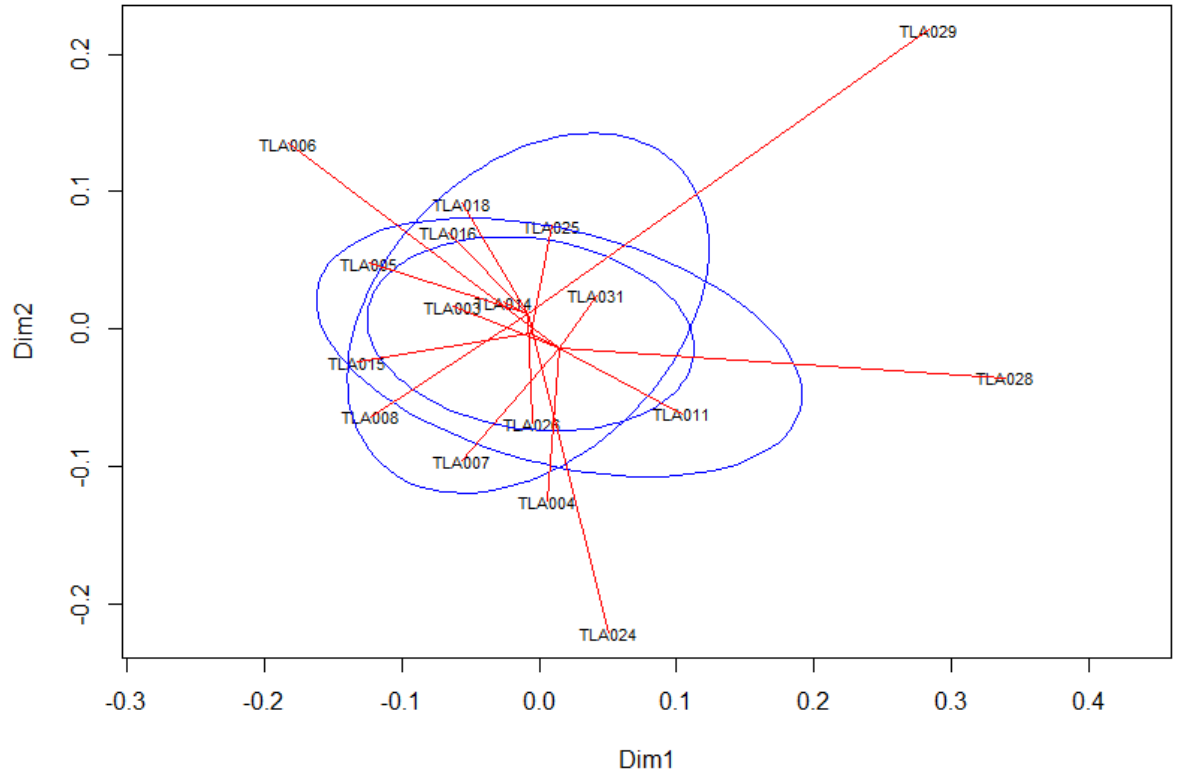


Figure 18. NMDS ordination mapping 17 most similar samples in species space (See Figures 16 and 17 for details). Here samples from each habitat (dense sand, sparse sand, rock) are connected by lines in a spider web diagram, and ellipses are drawn around area where samples from each habitat should occur in species space. The overlap in webs and ellipses indicate no difference in species composition among habitats.

Diatom Metrics for Different Habitats

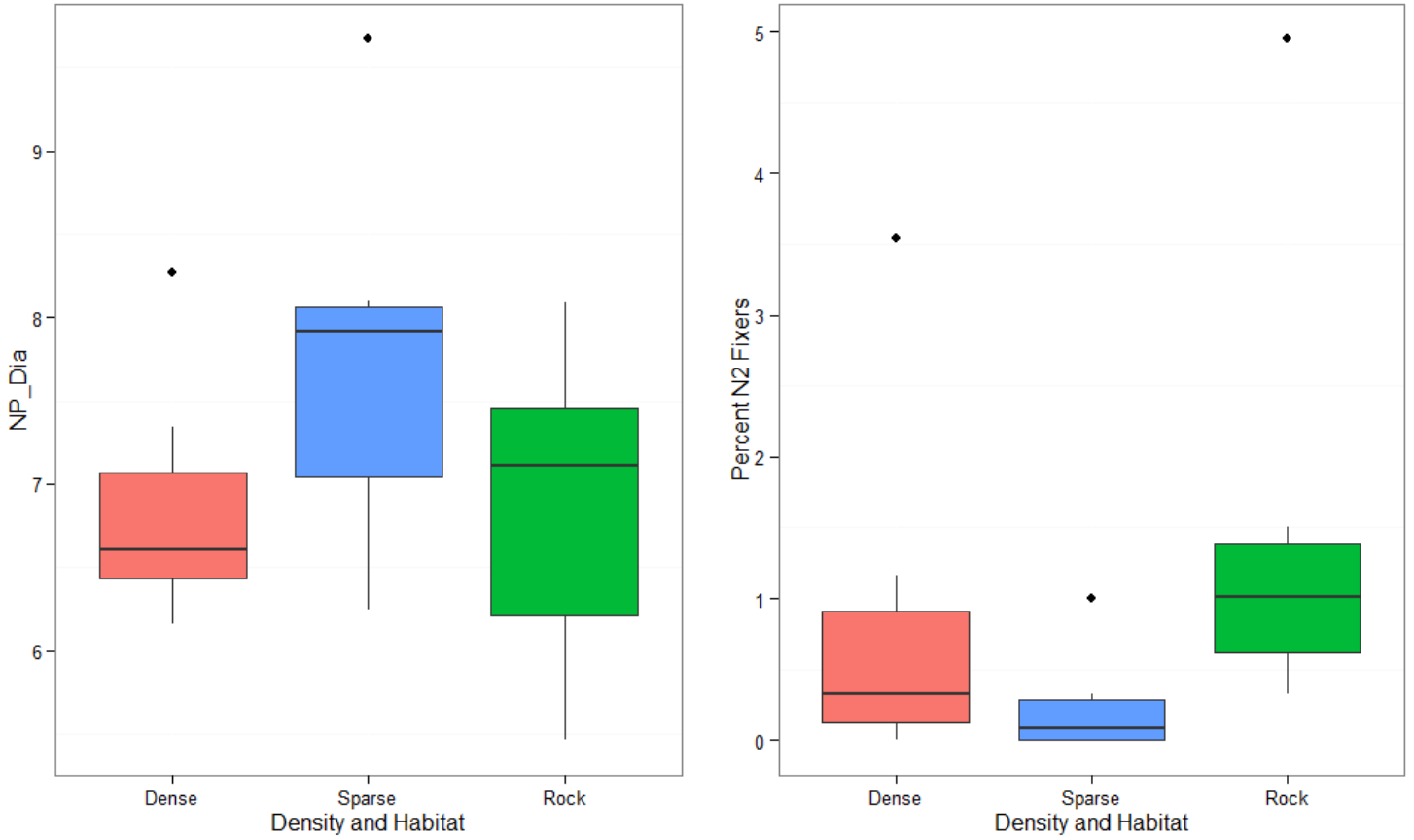


Figure 20. Differences in diatom metrics indicating nutrient concentrations (NP_Dia) and percent nitrogen fixers among dense sand (Dense), sparse sand (Sparse), and rock habitats.

Relationships between the diatom nutrient metric and water depth and between cells density and the diatom nutrient metric

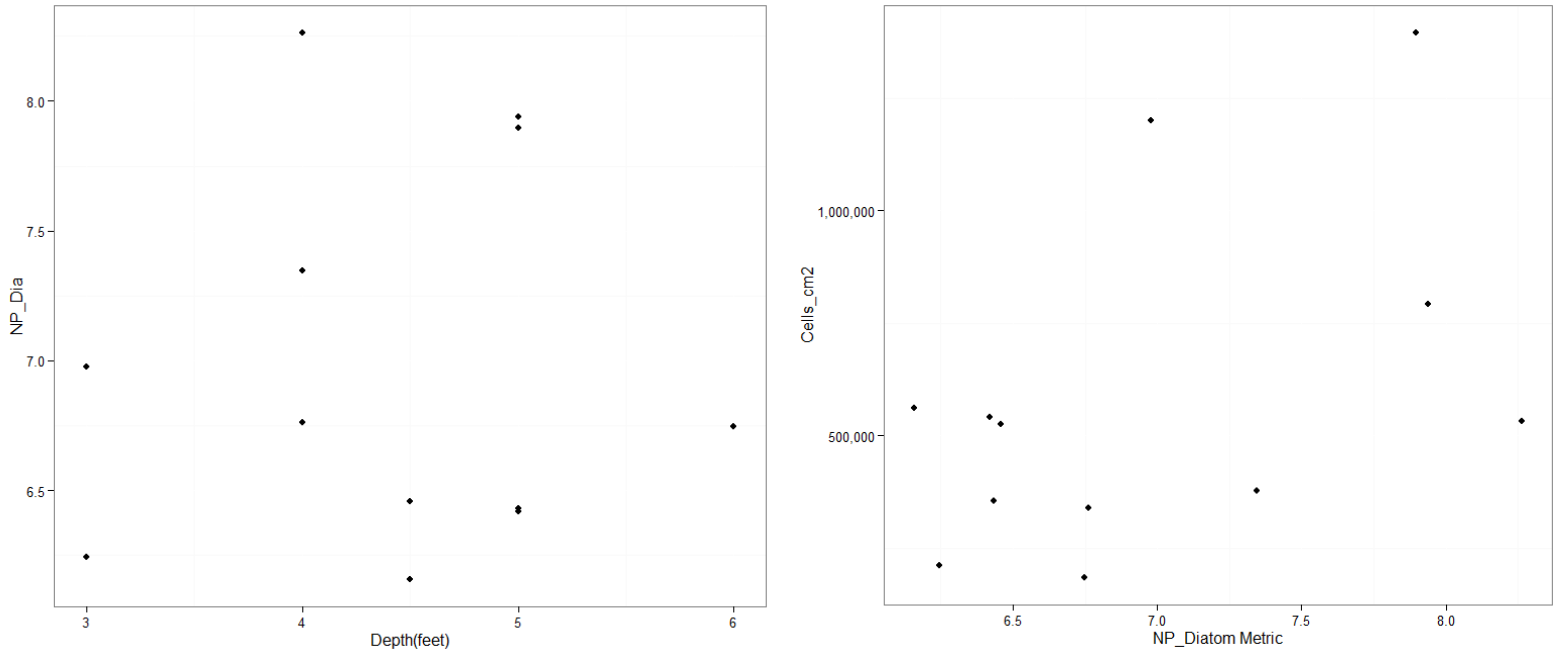
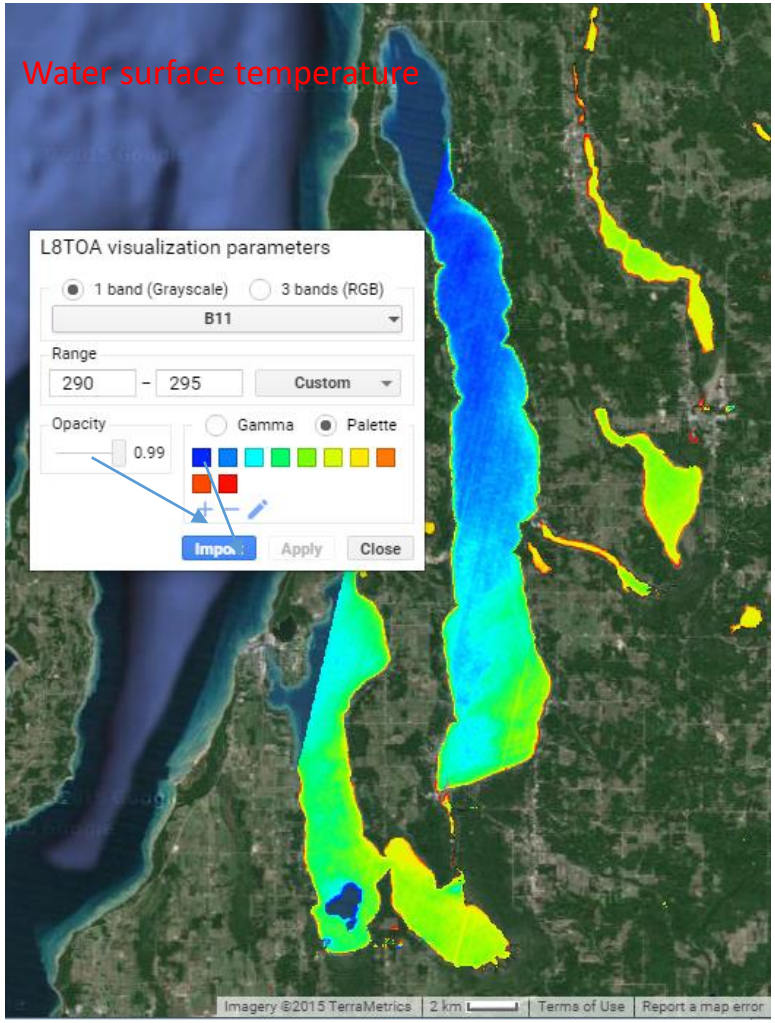


Figure 20. Relationships between the diatom nutrient metric and water depth and between cells density and the diatom nutrient metric for sand samples in Torch Lake.

Spatial Difference in Water Temperature

a)

b)



c)

Date: 10-JUL-15
Landsat 8 surface temperature
Spatial variation in Torch Lake:

	Kelvin °C	°C (K−273.15)
max:	294.8	21.7
mean:	290.9	17.8
min:	289.7	16.6
stdDev:	0.6	

Figure 21. Spatial differences in water temperature in Torch Lake from Landsat Imagery. a) regular red green blue image of southern tip of Torch Lake. b) Surface water temperature using band 11 of Landsat 8 in Torch Lake and surrounding lakes. c) Table of statistics for temperature variation in Torch Lake.

Seasonal Differences In Average Torch Lake Temperature

Water surface temperature (from Landsat 8, band 11)

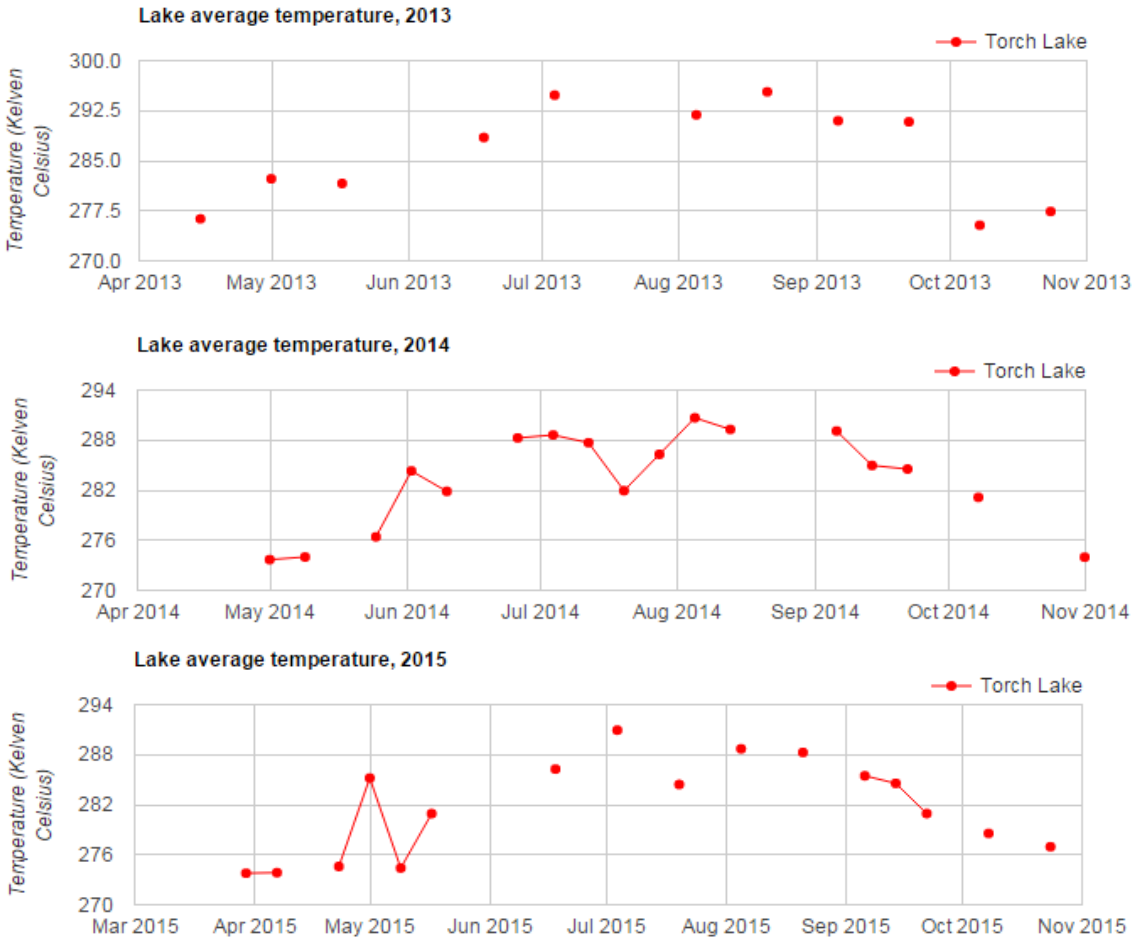


Figure 22. Average Torch Lake (degrees Kelvin) during the ice free seasons of 2013, 2014, and 2015. Observation points are connected by a line when cloudy images do not interrupt a series of measurements.

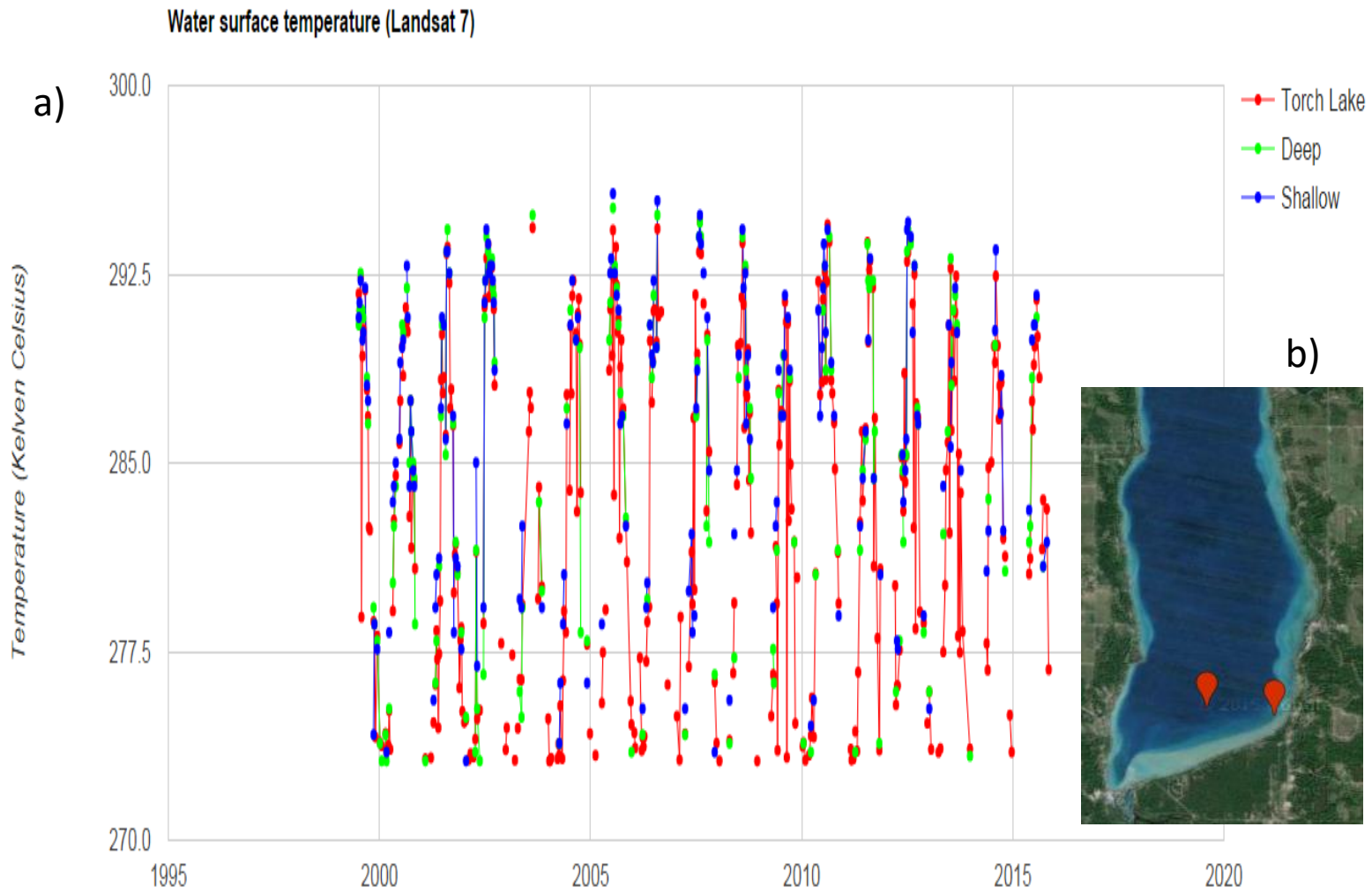


Figure 23. Changes in Torch Lake water temperature at a shallow (blue) and deep (green) location and across the lake (red). a) changes in temperature from spring 1999 through fall 2015.