Aquatic Fauna and Periphyton Production Data Collection
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Periphyton Component

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The utility of periphyton to expose ecological ramifications to restorative or deconstructive change in the Everglades is due its bearing several of the most desirable features of a reliable ecological indicator which include (1) being distributed throughout the system of study, (2) having rapid response to environmental change that is (3) readily quantifiable at several levels of biological organization (individual, species, population and community) with (4) consequences to levels above and below it's placement on the food web (Karr 1999). Reliance on periphyton to indicate environmental change has been well justified by scientific research conducted in the Everglades (McCormick & Stevenson 1998, Gaiser et al., 2006) which adds regional applicability to the existing body of literature in aquatic sciences that has supported the widespread employment of periphyton monitoring in aquatic ecosystem management (Hill et al., 2000; Stevenson 2001). Specifically, we anticipate that patterns of periphyton production, nutrient content and composition among and within the PSUs sampled in this mapping assessment will provide reliable indication of changes driven by hydrology and nutrient enrichment. Alterations in periphyton attributes then cascade through the system to affect higher organisms through changes in food quality, composition and concentration of gasses and nutrients in the water column and ecosystem structure (i.e., soil formation and quality, physical habitat structure).

The following hypotheses were formulated by the RECOVER assessment group using data from descriptive and experimental studies. We list the hypotheses and follow each with a discussion of supporting data and progress in application to this project.

H11b – Lengthened hydroperiods cause an increase in the proportion of floating, calcareous periphyton mat (associated with Utricularia purpurea) but when water depths exceed ~1-2 m, calcareous floating mats are replaced by epiphytic non-calcareous algal communities.

Supporting data: Studies along transects in compartmentalized Everglades wetlands showed hydrologically-driven gradients in periphyton mat structure (Gaiser et al., 2006). Water depths >~1.5 m supported non-calcareous algal communities while sloughs and marl prairies were dominated by thick, highly productive calcareous mats. Other long term studies have shown that calcareous mat productivity is highest in the short-hydroperiod wet prairie (Iwaniec et al., 2006; Ewe et al., 2006) where benthic, sediment-associated mats predominate. At slough sites, *Utricularia*-associated floating mats are less productive but show a distinct seasonality with marked increases in production during the peak of the wet season (Gaiser et al., 2006).

Progress: Although we have yet to incorporate site-specific hydroperiod estimates into our analysis of periphyton distribution patterns, we examined large-scale patterns in the cover of periphyton of different types during the dry and wet season sampling of 2005 and 2006. The cover types are shown in Figure 1 and include calcareous floating mat (associated with *Utricularia purpurea*), calcareous epiphyton (associated with submersed stems of emergent macrophytes), calcareous benthic mat (adhered to the sediment or rock surface), green filamentous algae (non-mat forming) and flocculent detritus (sampled when no other periphyton was available). We found substantial differences in periphyton cover by type as we move from the northern PSUs to the southern part of the system (Figure 2). For instance, sites in Lake Okeechobee, Pal Mar, Holeyland and Loxahatchee National Wildlife Refuge contained little calcareous mat and often had large quantities of filamentous green algae. This is likely a geologically-driven pattern rather than one driven by changes in nutrients or hydrology, per se, because these basins are not underlain by limerock that facilitates precipitation of carbonates. This is reflected in the pH values, which were comparatively low in the northern basins compared to areas further to the south (Figure 3). The continuance of the pattern of increasing calcareous biomass southward through the water conservation areas is likely largely driven by the corresponding decrease in P availability as well as hydroperiod with distance from canal inflows, as these same trends were observed in these basins in earlier transect studies (Gaiser et al., 2006). The increase in floc observed in the oligohaline zone at the very base of our study area reflects the input of particulate organic material from mangroves inhabiting this zone. There were no strong notable seasonal patterns in cover by substrate type, but continued regular sampling should improve our ability to detect such differences if they do exist.

H11c – Nutrient enrichment causes an elevation in periphyton nutrient content, a reduction in the proportion of calcareous floating and epiphytic periphyton mats, and a replacement of native species by non-mat forming filamentous species.

Supporting data: Throughout the system, periphyton has been proven to provide rapid and accurate indication of water quality changes; periphyton responses were critical to establishing the P criterion for freshwater sloughs (McCormick et al., 1996; Gaiser et al., 2004), have been used to indicate rates of coastal salt water encroachment in mangroves (Ross et al., 2001; Gaiser et al., 2004) and for detection of nutrient enrichment in adjacent offshore seagrass beds (Frankovich et al., 2006). Several studies have shown that periphyton not only respond to but also regulate water quality (Thomas et al., 2006; Gaiser et al., 2006) by quickly and efficiently removing excess P from the water column. Gaiser et al. (2005) recommends using periphyton P content as a metric of P enrichment history, rather than water or soil P, because it has been shown repeatedly to provide a much more reliable indication of P load history. This has been adopted in most large-scale monitoring programs in the Everglades (i.e., this study, the EPA REMAP assessment, FCE LTER research).

Progress: We found very strong and temporally consistent spatial patterns in periphyton biomass that showed a general increase from northern to southern PSUs (Figure 4). Periphyton biomass, measured by biovolume, cover, dry and ash-free dry mass all

increased to the south, becoming highest in Shark River Slough, the Southern Marl Prairie and Taylor Slough. The opposite pattern was observed for the total phosphorus, organic and chlorophyll a content of the periphyton. Total phosphorus values were highest in the flocculent periphyton of Lake Okeechobee, Pal Mar, Holeyland and Loxahatchee National Wildlife Refuge. They increased again in the oligohaline zone, where P delivery from marine and groundwater is likely (Childers et al., 2006; Price et al., 2006). There were no notable seasonal patterns in these values, although biomass has normally found to be highest in the wet season (Iwaniec et al., 2006). We suspect that continued sampling will reveal this weaker temporal trend.

The spatial patterns in periphyton attributes and total phosphorus content were highly correlated in expected ways. We found a strong and temporally persistent decrease in periphyton cover, biomass and biovolume with increasing total phosphorus content among sites (Figure 5). The organic content increased with total phosphorus availability, which is commonly observed as both a consequence and driver of the concomitant change in periphyton biomass (Gaiser et al., 2006). Notably, however, it is not just a loss of the calcitic matrix that occurs with phosphorus enrichment but a loss of biomass as well (Gaiser et al., 2005), as shown here in the strong negative correlation of ash-free dry periphyton biomass with total phosphorus content. An increase in the chlorophyll a content of that biomass with increased phosphorus availability is expected, as P availability increases productivity of cells in species with high P requirements. We observed a strong positive association of periphyton chlorophyll a with phosphorus, especially in the wet season of 2005 and dry season of 2006. There is a slightly positive correlation between phosphorus availability and water depth, although this trend was only significant in the wet season of 2005.

We also found strong spatial patterns in algal species composition among the PSUs. A total of 229 non-diatom algae and 155 diatom taxa were found in the 2005 survey of 148 sites (Tables 1, 2). Indicator species analysis (Dufrene & Legendre 1997) showed that some species were significantly associated with particular PSUs. Non-metric multidimensional scaling ordination biplots show that subsets of PSU's can be grouped by algal species composition (Figure 6). Communities in Pal Mar, Loxahatchee and Lake Okeechobee differ substantially from other PSU's. The water conservation areas group together on the other side of the biplot. The oligohaline zone is separated from the rest, likely because of the response of the algal community to increased salinity in this area. We found the first gradient in composition to be highly correlated with total phosphorus and negatively correlated with periphyton biomass. Communities associated with calcareous mats were also indicative of low phosphorus quantities, and vise-versa. We found that very productive mats with low TP and organic content were dominated by cyanobacteria while P-enriched communities of low biomass but high organic content were dominated by diatoms (Figure 7).

Because of this strong relationship between composition and total phosphorus availability, we were able to determine total phosphorus optima and tolerances for the most common taxa by weighted-averaging regression. The values reported in Tables 1 and 2 can be used to predict, by weighted averaging regression, the total periphyton P

content for sites in which these taxa are found. The prediction power of the model generated with these optima and tolerance values was measured by an $R^2 = 0.54$ and an RMSE of 53. This means that 54% of the variability in species distributions can be explained by phosphorus, and phosphorus predicted at any given site by the species is within 53 µg g-1 of its actual value. Mean TP values indicative of natural conditions vary among wetland PSUs but an error of 53 µg g-1 will be within 10-25% of the mean, suggesting a high predictive power of this model (Gaiser et al., 2006). There were strong trends in the residuals of this model that are important in evaluating the model's accuracy. The trends are related to the gradient reflected in the second axis of the NMDS which is correlated with pH, water and soil depth. Areas of deeper soils are also deeper and peat-forming, causing a reduction in the pH, which is known to be a strong driver of algal community composition. Future models must take this second important gradient into account, indicating that algal-based P inference models will be strongest when created and employed in a regionally-specific manner. The next step in our modeling efforts will be to create such regionally-explicit P-inference models. Basin-specific P-prediction models presented in Gaiser et al. (2006) had much higher predictive power than whole system models, suggesting that model development on a smaller scale is also an appropriate approach in this survey. Conversely, multiple models are more cumbersome so our next steps are to (1) develop a multi-parameter model for the entire system (that explains residual trends driven by large scale variability, above) and (2) develop explicit P-prediction models for each PSU and, by cross-validating across PSUs, determine the optimal scale for a univariate prediction model. We believe that the latter approach will be most powerful, as it will facilitate direct interpretation of eutrophication trends from periphyton species data.

H11a – Shortened hydroperiods cause a reduction in the proportion of diatoms and green algae and an increase in calcareous blue-green algae, possibly reducing food value of periphyton, and affecting overall productivity of the Everglades.

Supporting data: Compositional responses of periphyton to hydrologic change were quantified in field and laboratory studies by Gottlieb et al. (2006 a, b) and Thomas et al. (2006). Gottlieb et al. (2006 a) found marked differences between algal communities in long and short-hydroperiod marshes of Everglades National Park and derived hydrologic optima and tolerances for the most abundant species. Thomas et al. (2006) and Gottlieb et al. (2006) conducted drying and re-wetting experiments to determine the length of time it takes the community to be measurably altered when exposed to an alternative hydroperiod, and found significant change within days to weeks of exposure. Further, studies by Geddes et al. (2003) and Dorn et al. (2006) documented the connection between periphyton composition and consumers showing that the two are connected partly through the periphyton-derived detrital food web and also through nutrient regeneration by the animals.

Progress: We found a decrease in water depth from the water conservation areas to the base of Shark River and Taylor Slough that roughly corresponds to reductions in hydroperiod, although site-specific hydroperiod estimates have not yet been incorporated into this analysis (Figure 3). This decrease in water depth was associated

with an increase in periphyton biomass with decreased organic and total phosphorus content (Figures 3-5). Water depth also explained compositional differences among sites with deeper water generally being associated with increased abundance of diatoms and reduced abundances of cyanobacteria (Figure 7) while benthic mats in shallow habitats had low TP and organic content and were dominated by cyanobacteria and reduced abundances of diatoms and green algae (Figure 7). Our next step in this analysis is to incorporate site-specific hydroperiod predictions (generated from EDEN) to quantify hydrologic controls on periphyton trends.

To determine if alterations in periphyton composition affect inferred food quality for invertebrate and fish consumers, we have begun to explore the relationships between periphyton atteributes and fish and macroinvertebrate density. We found reduced numbers of fish and macroinvertebrates with increasing periphyton biomass, which is likely due to the reduced quality of periphyton in short-hydroperiod marshes. These mats are highly calcareous rendering them difficult to graze by many consumers (Geddes et al., 2003). As the organic content of periphyton increased, we found increasing abundances of herbivorous invertebrates (except crayfish) and fish (Figure 8). There were some taxon-specific associations between the herbivore communities and algae, with the abundance of grass shrimp (*Palaemonetes paludosus*) increasing with algae of higher organic content while crayfish abundance was associated with high TP diatom communities (Figure 6). When algae were grouped into higher level taxonomic categories (i.e., cyanophytes, chlorophytes, diatoms) we found even greater associations with the grazer community. For instance, the number of grass shrimp, other grazing macroinvertebrates and fish declined with increasing abundance of filamentous cyanobacteria (Figure 9). This is likely due to the decreased quality of blue-green-dominated mats that not only mechanically deter filter feeders but reduce palatability through the calcium carbonate precipitated on their sheaths and through production of antimicrobial toxins. Conversely, these three consumer groups increased with diatom and green algal abundance probably due to the increased nutritional value of these algal groups. This was our first attempt to link the consumer and periphyton data and we are planning a much more sophisticated analysis at more appropriate spatial scales to better tease apart the underlying consumer-food resource relationships.

2. Communicating the Periphyton Indicator

Periphyton plays a critical role in the food web as a food source and prey refuge. Given its extremely high rates of production (Iwaniec et al., 2006), the vast areas of South Florida marsh covered by periphyton may represent a significant sink for carbon, another important functional role of the Everglades from a global perspective. Taxonomic diversity of microbial organisms that comprise periphyton is higher than most other biotic communities, thereby making a substantial contribution to system biodiversity estimates. Functional consequences of this diversity are unexplored, yet literature would support the contention that it is because of this diversity that algal-microbial communities make such reliable ecological indicators.

2.1. Indicator Performance Measures and Metrics

Several metrics provide reliable measure of periphyton response to hydrologic and water quality change in this system. They can be broadly grouped into three categories of abundance, quality and community composition. Within these categories at least three measures are recorded within the context of CERP assessment. These include, for abundance, wet biovolume (ml m^{-2}), dry biomass (g m^{-2}) and ash-free dry biomass (g m^{-2}); for quality, organic content (µg dry g^{-1}), chlorophyll a content (µg dry g^{-1}) and total phosphorus content (µg dry g^{-1}); and, for the community category, algal composition and diatom composition (measured using similarity metrics in multi-dimensional ordination space) and substrate affiliation (percent cover by substrate type).

Within each of the categories, all of the parameters respond in the same direction (positive or negative) to changes in hydrologic conditions, including depth, duration, timing, and spatial extent, as well as water quality (Gaiser et al., 2006). The periphyton biomass metrics of wet biovolume, dry biomass and ash-free dry biomass, expressed on a per square meter basis, are correlated with each other all decline with increasing water depth and hydroperiod and with increasing availability of phosphorus (Gaiser et al., 2006; Ewe et al., 2006). The periphyton quality metrics of organic, chlorophyll *a*, and total phosphorus content, expressed per unit dry mass, are correlated with each other and increase with increasing water depth and hydroperiod and with increasing availability of phosphorus (Gaiser et al., 2005, 2006). The communityl metrics are based on compositional similarity to expected community structure, established from collections at reference locations (according to Gaiser et al., 2006). Periphyton cover by substrate type is dealt with in a similar manner, where substrate types are given optima and tolerances along each gradient based on their distribution, and then site water quality predictions based on those optima weighted by relative cover.

2.2. The Stoplight Report Card System applied to Periphyton

The stoplight system for periphyton involves first calibrating the tri-color code by the deviation of values for each metric from an expected baseline condition for each sampling point (Figure 10.). Triplicate samples from principal sampling units (PSU's, randomly selected locations within landscape sampling units, LSU's) visited annually in the mid-wet season are analyzed for each periphyton metric. PSU means are then compared to expected values for background conditions defined for the respective LSU. Background conditions are defined from data collected or inferences made from locations within the LSU that are considered un-impacted by human activities and are not static; that is, ranges of acceptable conditions may change depending on modifications by external drivers not under our control (i.e., climate variability) and advancements in the understanding of the ecosystem. Development of a consistent baseline necessitates long-term data, so we do expect targets to evolve as the duration of monitoring programs grow. However, any changes in baseline expectations will be documented and then hindcast through the stoplight system to re-calibrate former values.

2.3. How We Determine Thresholds for Periphyton Success (Green), Caution (Yellow) or Failure (Red)

Once baseline expectations for each of the 9 variables are established, color codes are assigned to each PSU based on deviation from that expectation. If the value is within one standard error of the mean, it is designated green (natural), within two standard errors is designated yellow (caution) and beyond three standard errors is designated red (altered) (see Figure 10). The PSU is then assigned a color for biomass, quality and community composition. The distribution of color designations can then be mapped by PSU for each of these three performance measures. The final color designation for each LSU is then based on the percentage of yellow and red sites. An LSU is given a final yellow designation if more than 25% of sites are coded yellow or red and a red designation if more than 50% of the sites are red, with these cut-offs being based on variability determined within unimpacted background sites (Gaiser et al., 2006).

Baseline expectations for periphyton TP content, ash-free dry biomass and composition for some LSU's are fairly well-defined and so we provide an example using those data. The expected ranges for these variables for un-impacted conditions for WCA-1A, WCA-2A, WCA-3A, SRS and TS were defined by transect surveys conducted in these areas in 1999 by Gaiser et al., (2006). As stated, green coding was used to define acceptable ranges defined by the mean values of unimpacted sites +/- 1 standard error of that mean, yellow for values between 1-2 standard errors and red for sites departing more than 2 standard errors from the mean. Figure 10 shows how each basin has unique ranges of acceptable values and how each attribute scales differently. Data from 2005 and 2006 CERP Mapping surveys were plotted on these graphs to show the proportion of sites falling in each of the colored regions.

For annual assessments, a map of the distribution of the periphyton TP indicator is displayed (Figure 11) to show within and among-region pattern. Pattern and suspected causes are displayed in the "summary" and "key findings" sections (see stoplight report). Each basin is then assigned a value (again using the green-yellow-red coding) based on the proportion of sites falling into these ranges (explained above). Explanation is then provided for causes of current conditions and prospects for 2 years in the future if water management remains the same.

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Table 1. List of the most common algal taxa in samples from the Fall 2005 survey, with the number of sites present (of 148), their maximum relative abundance, total phosphorus optimum (in $\mu g\ g^{-1}$ periphyton dry weight, calculated by weighted averaging) and the location for taxa significantly associated with a particular sampling unit.

Taxon	Freq.	Max	Opt. TP	Location
Achnanthes caledonica	33	10	286	
Achnanthes gracillima	7	6	298	
Achnanthes minutissima	4	1	843	
Amphora coffeaformis	2	9	624	
Amphora sulcata	13	19	319	Holeyland
Anabaena spp.	13	1	565	
Ankistradesmus	2	0	506	
Anomoeoneis sphaerophora f. *costata*	1	0	103	
Aphanocapsa spp.	29	3	255	
Aphanothece spp.	148	63	382	
Bacillaria paxillifer	1	0	478	
Brachysira aponina	1	1	463	
Brachysira brebissonii	23	36	659	Okeechobee
Brachysira neoexilis	120	13	356	
Brachysira neoacuta	6	1	421	
Bulbochaete sp. 1	22	6	422	
Caponea caribbea	2	0	111	
Centritractus spp.	6	1	389	
Characium spp.	4	1	381	
Chroococcidiopsis sp.	44	34	938	Okeechobee
Chroococcus morph large	61	7	262	
Chroococcus morph small	121	10	262	
Closterium spp.	4	0	149	
Coelastrum spp.	8	1	202	
Coelosphaerium spp.	67	8	248	
Coscinodiscus spp.	3	2	258	
Cosmarium commisurale	6	2	289	
Cosmarium contractum	17	2	308	WCA 2A
Cosmarium cf. *depresessum*	6	1	300	WCA 2A
Cosmarium excavatum	3	0	183	
Cosmarium isthmium	2	1	290	
Cosmarium monomazum	2	1	215	
Cosmarium ocellatum	6	1	208	
Cosmarium phaseolus	10	1	554	
Cosmarium pyramidatum	16	4	627	
Cosmarium reniforme	11	2	648	
Cosmarium spp.	76	2	403	
Crucigenia quadrata	2	0	515	
Cyclotella meneghiniana	7	2	731	
Dactylococcopsis sp.	1	0	81	
Desmidium baileyii	29	9	328	
Desmidium schwartzii	16	8	361	
Desmidium sp.	3	6	719	Pal Mar
Diadesmis confervacea	1	5	1759	

Diploneis oblongella	4	0	255	
Diploneis parma	20	6	918	
Diploneis puella	1	0	1759	
Encyonema evergladianum	126	40	246	
Encyonema sp. 1	40	6	313	
Encyonema sp. 2	76	6	399	
Encyonema sp. 4	5	1	233	
Encyonema silesiacum var. *elegans*	23	11	530	Holeyland
Encyonema sp. 3	6	1	218	
Encyonema spp.	2	1	795	
Encyonopsis microcephala	76	16	417	Pal Mar
Encyonopsis sp. 1	16	10	628	Holeyland
Encyonopsis subminuta	15	4	551	
Euastrum cornubiense	20	1	323	
Euastrum pectinatum	8	0	442	
Euastrum small morph	17	1	326	
Euastrum spp.	8	1	284	
Eunotia camelus	2	0	1260	
Eunotia flexuosa	7	8	1495	
Eunotia incisa	6	1	955	
Eunotia monodon	5	1	569	Pal Mar
Eunotia naegelii	19	7	1073	Okeechobee
Eunotia rabenhorstiana var. elongata	3	0	1105	
Eunotia spp.	11	1	687	
Fischerella spp.	6	4	317	
Fragilaria nana	44	18	551	
Fragilaria spp.	4	3	870	
Fragilaria synegrotesca	105	24	323	Loxahatchee
Fragilaria ulna	3	2	694	
Fragilariforma spp.	19	11	537	Okeechobee
Frustulia rhomboides	2	1	310	
Genicularia elginensis	20	1	195	
Gloeocapsa spp.	1	0	400	
Gloeotaenium spp.	5	1	204	
Gloeocystis spp.	19	3	327	
Gloeothece spp.	138	22	279	
Gomphonema affine	1	1	1759	
Gomphonema auritum	2	0	703	
Gomphonema coronatum	1	1	591	
Gomphonema gracile	7	0	345	
Gomphonema intricatum var. *vibrio*	33	3	452	
Gomphonema maclaughlinii	1	0	661	
Gomphonema parvulum var. *lagenula*	1	0	1000	
Gomphonema pratense	1	0	661	
Gomphonema spp.	4	0	1221	
Gomphonema vibrioides	11	2	202	
Gonatozygon spp.	6	0	290	
Gomphosphaeria spp.	73	7	369	
Hantzschia amphioxys	1	0	1759	
Johannesbaptista sowerbyi	3	1	138	

Kirchneriella spp.	1	0	434	
Lagynion spp.	4	1	468	
Lemnicola hungarica	1	1	65	
Lyngbya spp.	77	24	250	
Mastogloia lanceolata	5	25	574	
Mastogloia smithii	125	38	268	
Mastogloia smithii var. *lacustris*	1	0	315	
Micrasterias crux-mellitensis	2	0	161	
Micrasterias pinnata	4	1	381	Loxahatchee
Micrasterias spp.	69	9	381	
Microchaete spp.	2	1	627	Pal Mar
Mougeotia large morph	10	3	408	
Mougeotia small morph	16	9	504	
Mougeotia spp.	2	0	133	
Navicula constans	1	1	1759	
Navicula cryptocephala	2	0	535	
Navicula cryptotenella	38	2	332	
Navicula palestinae	2	19	572	
Navicula radiosa	19	1	302	WCA 2A
Navicula radiosafallax	18	1	266	
Navicula spp.	1	5	1759	
Navicula subtilissima	31	1	306	WCA 2A
Nitzschia amphibia	16	9	1049	Okeechobee
Nitzschia nana	6	2	1329	Okeechobee
Nitzschia lacunarum	31	3	585	
Nitzschia palea var. *debilis*	119	19	383	
Nitzschia serpentiraphe	45	3	190	Loxahatchee
Nitzschia spp.	8	7	775	
Oedogonium (large)	16	3	302	
Oedogonium (small)	50	7	429	
Onychonema spp.	6	3	419	Pal Mar
Oocystis spp.	27	2	281	
Oscillatoria spp.	8	4	581	
Palmodictyon spp.	1	0	324	
Pediastrum tetras	3	0	156	
Peridinium spp.	63	2	261	
Pinnularia gibba	5	1	1193	
Pinnularia spp.	15	1	784	
Pinnularia microstauron	4	1	964	
Pleurotaenium minutum var. *attenuatum*	73	6	233	
Pleurotaenium minutum var. *excavatum*.	71	8	302	
Pseudostaurosira brevistriata	4	1	561	
Rhabdoderma linearis	134	16	232	
Rhabdoderma sigmoidea	86	10	210	
Rhopalodia gibba	4	1	206	
Rossithidium lineare	2	2	857	
Scenedesmus acutus	0	0	...	
Scenedesmus armatus	2	1	1162	
Scenedesmus brevistriata	2	3	203	WCA 3AN
Scenedesmus serratus	2	1	158	

Scenedesmus spp.	6	1	209	
Schizothrix spp.	144	58	233	
Scytonema hofmannii morph 1	34	17	118	WCA 3AN
Scytonema hofmannii morph 2	60	15	200	
Scytonema hofmannii morph 3	116	29	241	
Sellaphora laevissima	6	0	212	
Sellaphora pupula	1	2	1759	
Staurastrum connatum	8	1	483	
Staurastrum cyathipes	2	0	446	
Staurastrum excavatum	64	5	426	
Staurastrum longebrachiatum	15	1	504	Holeyland
Staurastrum ophiurum f. *cambriatum*	3	0	534	
Stauroneis phoenicenteron	4	1	478	
Staurastrum cf. *sonthalium*	2	0	170	
Staurastrum spp.	10	2	321	Okeechobee
Stenopterobia curvula	4	0	527	Pal Mar
Stigeoclonium spp.	2	1	489	
Stipiticoccus spp.	75	3	274	
Teilingia spp.	7	4	416	
Tetraedron caudatum	2	0	671	WCA 2A
Tetraedron pentaedricum	4	1	335	
Tetraedron spp.	22	1	336	
Thalassiosira spp.	3	1	1013	
Triploceras spp.	3	2	165	

Table 2. List of the most common diatom taxa in samples from the Fall 2005 survey, with the number of sites present (of 148), their maximum relative abundance, total phosphorus optimum (in µg g^{-1} periphyton dry weight, calculated by weighted averaging) and the location for taxa significantly associated with a particular sampling unit.

	Freq.	Max	TP Opt.	Location
Achnanthes caledonica L-B	38	12	408	
Achnanthes cf. *minutissima* var. *gracillima* (Meist.) L-B	5	3	242	
Achnanthidium minutissimum (Kütz.) Czar.	5	2	768	
Achnanthidium minutissimum (Kütz.) Czar. morph. 1	8	2	383	
Amphora copulata (Kütz.) Schoen. & Arch.	5	1	341	
Amphora pseudoproteus	1	1	506	
Amphora sulcata Bréb.	16	45	332	Holeyland
Amphipleura pellucida Kütz.	3	1	518	
Bacillaria paxillifer (O. F. Mull.) Hendey	2	1	1243	
Brachysira aponina Kütz.	5	1	215	
Brachysira brebissonii Ross in Hartley	29	64	495	Okeechobee
Brachysira neoexilis Lange-Bertalot	136	45	318	
Brachysira procera Lange-Bertalot & Moser	44	5	270	
Brachysira pseudoexillis Lange-Bertalot & Gerd Moser	68	13	137	
Brachysira vitrea (Grun.) Ross in Hartley	28	2	441	
Caloneis bacillum (Grun.) Cl.	2	4	1597	
Caponea caribbea Podzorski	3	1	420	
Cocconeis placentula var. *euglypta* (Her.) Grun.	4	1	154	
Craticula cuspidata (Kütz.) Mann	2	1	1195	
Cyclotella meneghiniana Kütz.	48	2	400	
Diadesmis confervacea (Kütz.) Grun. in Van Heurck	2	0	1243	
Diploneis oblongella (Naegelii ex. Kütz.) R. Ross	21	1	255	
Diploneis parma Cleve	69	27	842	
Diploneis elliptica (Kütz.) Cl.	3	3	761	
Encyonopsis sp.	25	47	593	Holeyland
Encyonopsis microcephala (Grun) Krammer	83	36	482	Pal Mar
Encyonema sp. 1	2	1	155	
Encyonema evergladianum Krammer	123	68	210	
Encyonema sp. 2	130	53	459	WCA 2A
Encyonema sp. 3	2	1	66	
Encyonema silesiacum var. *elegans*	54	21	520	Okeechobee
Encyonema silesiacum (Bleisch *ex* Rab.) Mann	10	2	592	
Encyonema sp.	11	2	244	
Eunotia camelus Ehr.	12	2	983	Okeechobee
Eunotia sp. 1	14	39	404	
Eunotia flexuosa Bréb. ex. Kütz.	35	11	951	Okeechobee
Eunotia incisa W. Smith ex. Gregory	20	3	770	Pal Mar
Eunotia monodon Ehr.	6	2	698	Pal Mar
Eunotia naegelii Migula	30	27	1192	Okeechobee
Eunotia rabenhorstiana v. *elongata* (Patrick) Metz. & L-B	7	2	697	Holeyland
Fragilaria capucina Desm.	7	1	955	Okeechobee
Fragilaria nanana Lange-Bertalot	46	8	490	
Fragilaria synegrotesca Lange-Bertalot	132	44	332	
Fragilaria ulna [danica complex] (Nitz.) Lange-Bertalot	6	2	744	
Fragilaria ulna (Nitz.) Lange-Bertalot	6	5	698	

Fragilariforma virescens v. *capitata* (Ralfs) Williams & Round	17	1	297	Loxahatchee
Frustulia rhomboides (Her.) de Toni	23	23	505	Okeechobee
Frustulia crassinervia (Bréb.) Lange- Bertalot & Krammer	7	2	448	
Gomphonema affine Kütz.	5	4	1113	
Gomphonema auritum Braun	5	4	1311	
Gomphonema coronatum Ehr.	2	1	480	
Gomphonema gracile Ehrenberg emend. Van Heurck	18	4	613	
Gomphonema intricatum var. *vibrio* Ehr. (Cl.)	106	9	481	
Gomphonema maclaughlinii Reich.	3	1	726	
Gomphonema parvulum var. *lagenula* L.B. & Reich.	5	2	834	
Gomphonema vibrioides Reichardt et Lange-Bertalot	24	2	368	
Mastogloia braunii Grun.	1	2	506	
Mastogloia lanceolata Thwaites ex. W. Sm.	8	6	397	
Mastogloia smithii var. *lacustris* Grunow	19	58	330	
Mastogloia smithii Thwaites ex. W. Sm.	131	88	238	
Navicula angusta Grun.	2	1	636	
Navicula cryptotenella Lange-Bertalot	80	16	481	
Navicula palestinae	1	5	506	
Navicula radiosa Kütz.	65	6	366	
Navicula radiosafallax Lange-Bertalot	21	3	368	
Navicula salinicola Hustedt	1	14	506	
Navicula subtilissima Cl.	52	9	236	
Navicella pusilla (Grun. ex. Schmidt) K.	3	2	294	
Neidium ampliatum (Ehr.) Kramm.	4	0	592	
Nitzschia amphibia var. *amphibia* Grun..	48	17	932	Okeechobee
Nitzschia amphibia var. *frauenfeldii* (Grun.) Lange-Bertalot	2	1	866	
Nitzschia cf. *obtusa* Wm. Sm.	3	4	434	
Nitzschia lacunarum Hustedt in A. Schmidt et al.	3	1	469	
Nitzschia nana Grun. in Van Heurck	17	39	1059	Okeechobee
Nitzschia palea var. *debilis* (Kütz.) Grun.	114	27	248	
Nitzschia palea (Kütz.) W. Sm.	29	6	733	Okeechobee
Nitzschia serpentiraphe Lange-Bertalot	78	31	92	
Pinnularia acrosphaeria W. Sm.	2	5	888	
Pinnularia gibba Ehr.	6	1	296	Okeechobee
Pinnularia gibba Ehr. Morph 2	12	5	1081	
Pinnularia microstauron (Ehr.) Cl.	10	2	762	
Pinnularia stomatophora (Grun.) Cl.	5	1	686	
Pinnularia viridiformis Krammer	13	3	626	Pal Mar
Pseudostaurosira brevistriata (Grun. in V.H.) Williams & Round	4	1	1051	Pal Mar
Rhopalodia gibba (Ehr.) O. Müll.	12	1	891	
Rhopalodia brebissonii Kr.	2	1	838	
Rossithidium lineare (W. Sm.) Round & Bukht.	5	2	591	
Sellaphora laevissima (Kütz.) Mann	18	1	179	
Sellaphora pupula (Kütz.) Mereschk	8	3	1051	
Stenopterobia curvula (W. Sm.) Kr.	7	2	659	
Stauroneis javanica (Grun.) Cl.	2	1	595	
Stauroneis phoenicenteron (Nitz.) Ehr.	13	6	544	
Terpsinoe sp.	1	1	570	

Figure 1. Photos showing the different types of periphyton mats categorized in this study: A) calcareous floating mat, B) calcareous epiphytic mat, C) calcareous benthic mat and D) filamentous green periphyton.

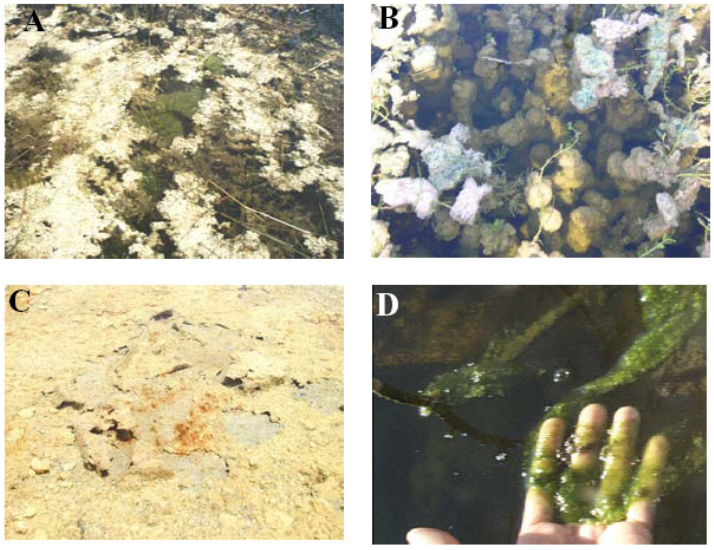

Figure 2. Patterns in periphyton cover categorized by substrate type among the different localities sampled in the dry and wet seasons of 2005 and 2006.

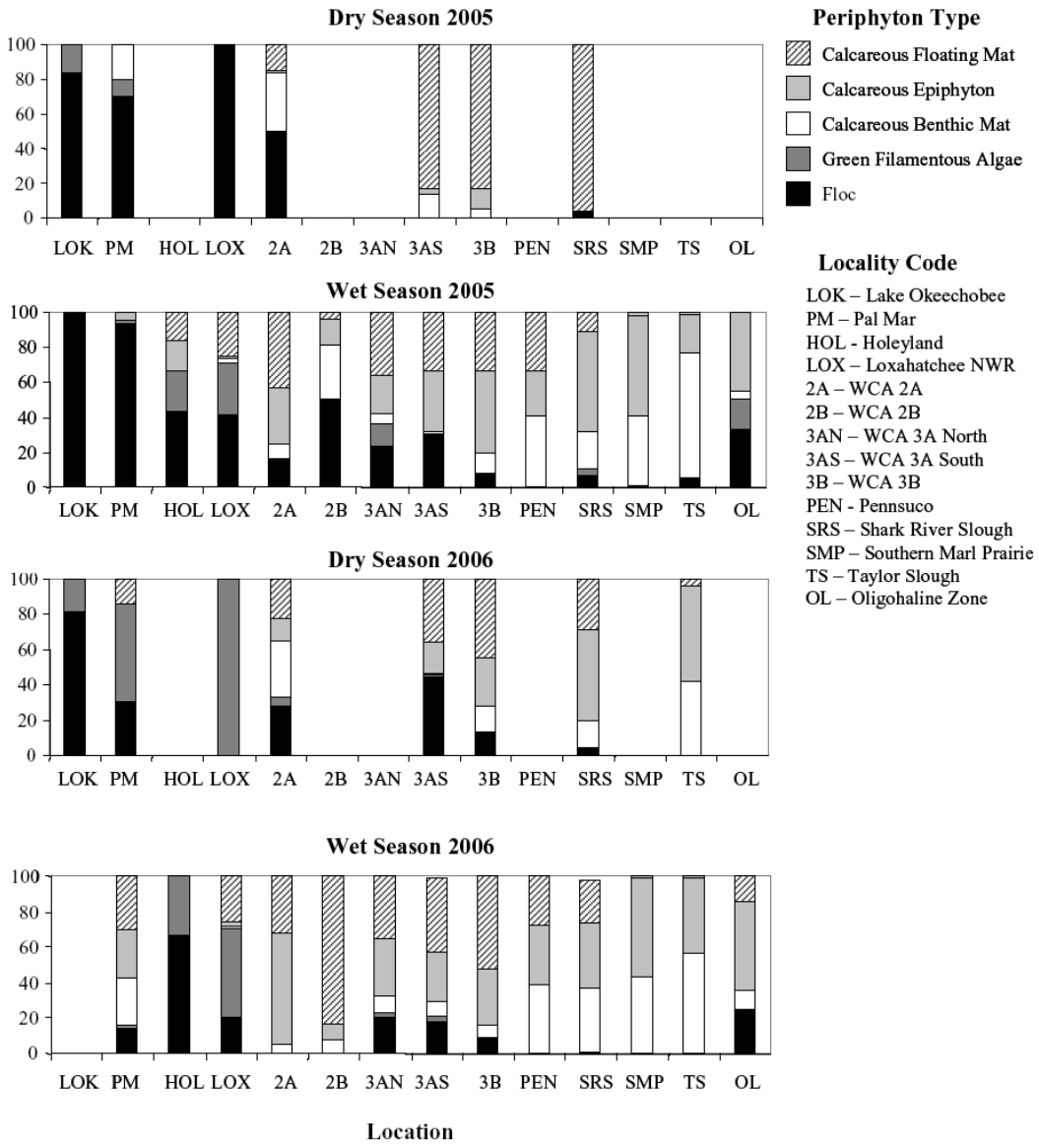

Figure 3. Patterns in field-measured variables including water depth, pH, soil depth and periphyton volume and cover in the dry and wet seasons of 2005 and 2006. See Figure 1 for locality codes.

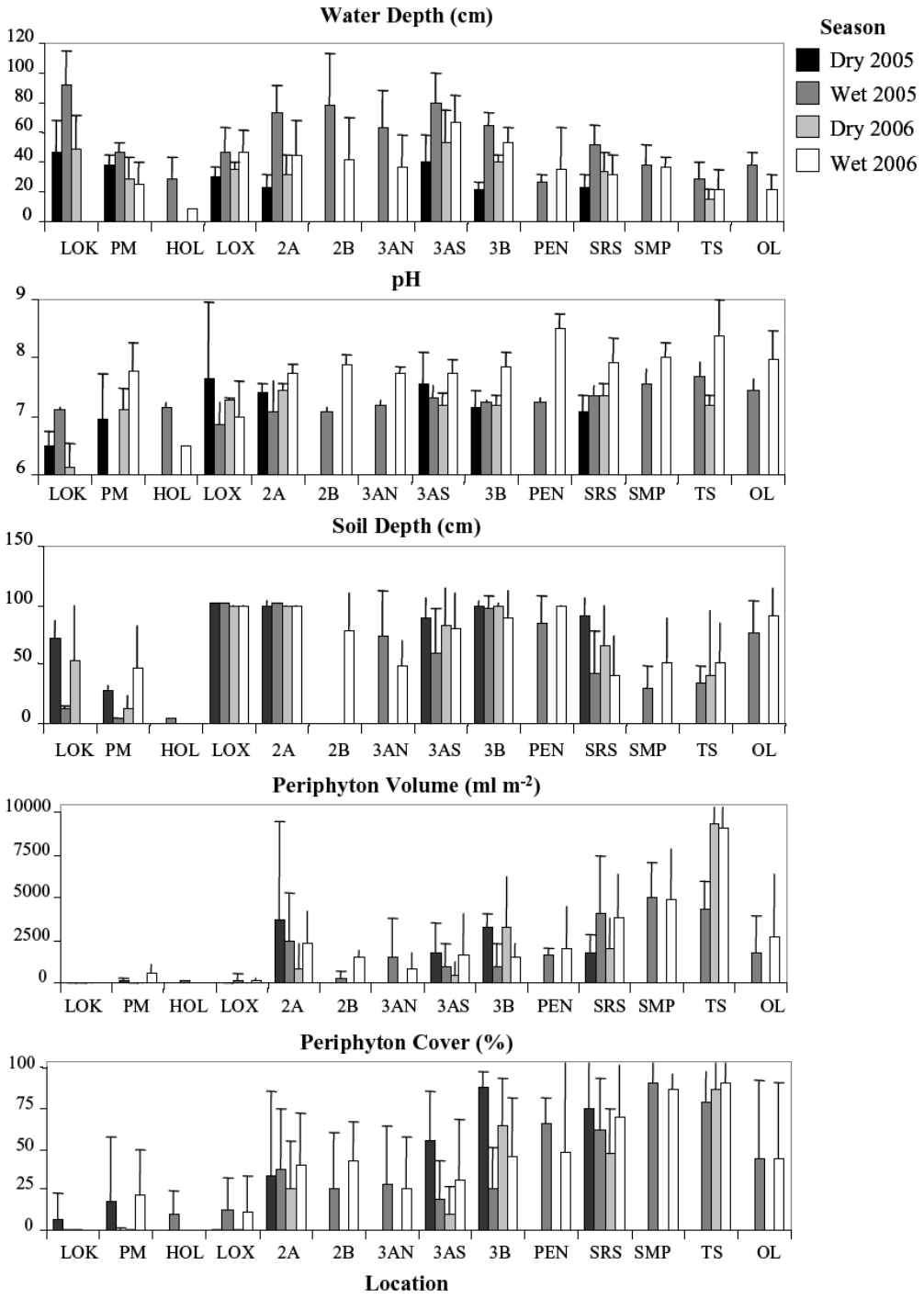

Figure 4. Patterns in periphyton total phosphorus content, biomass, organic and chlorophyll a content among locations in the dry and wet seaons of 2005 and 2006. See Figure 1 for locality codes.

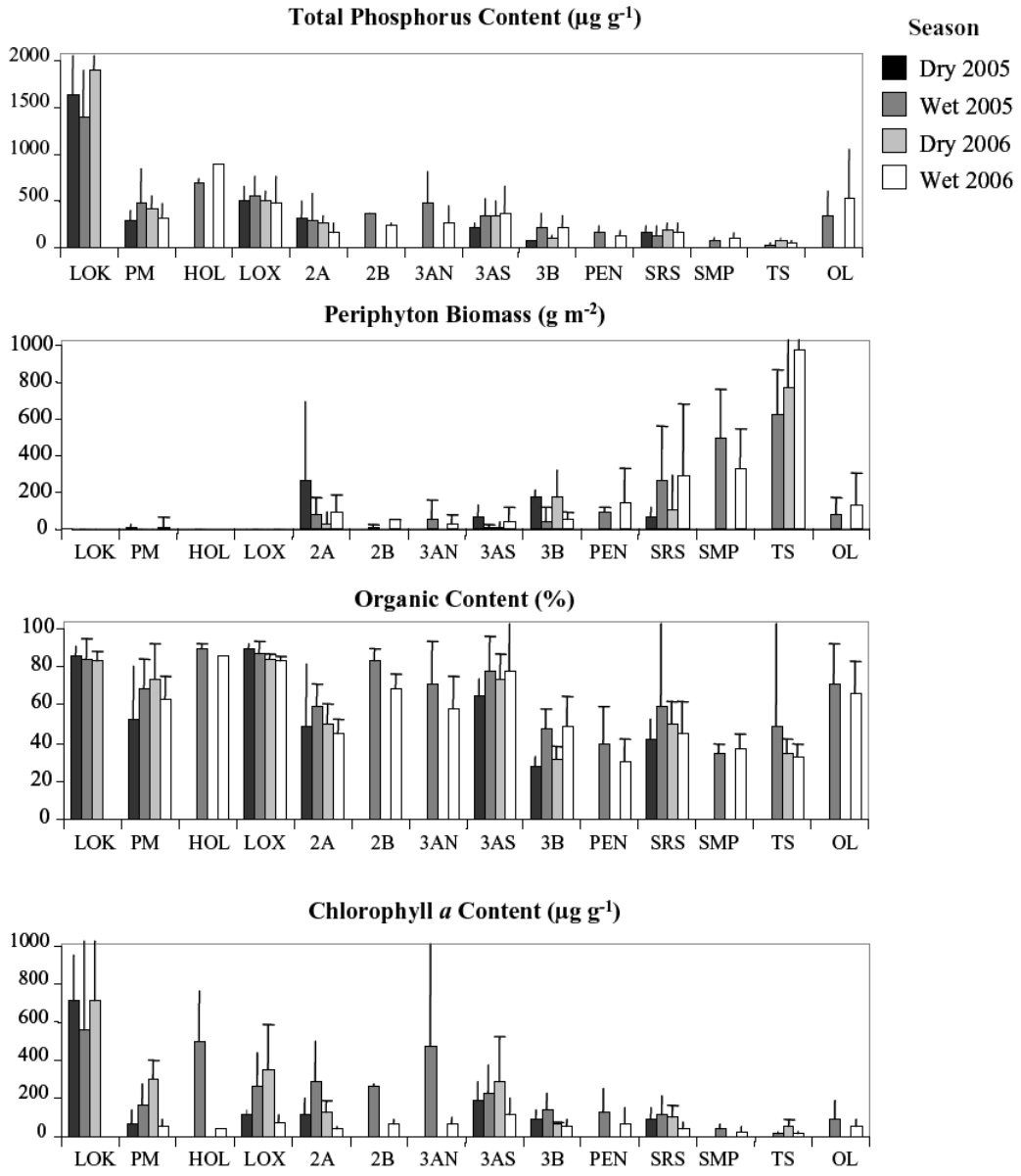

Figure 5. Relationships of periphyton total phosphorus to cover, biovolume, biomass, water depth and periphyton organic and chlorophyll a content averaged within PSU's during the dry and wet seasons of 2005 and 2006.

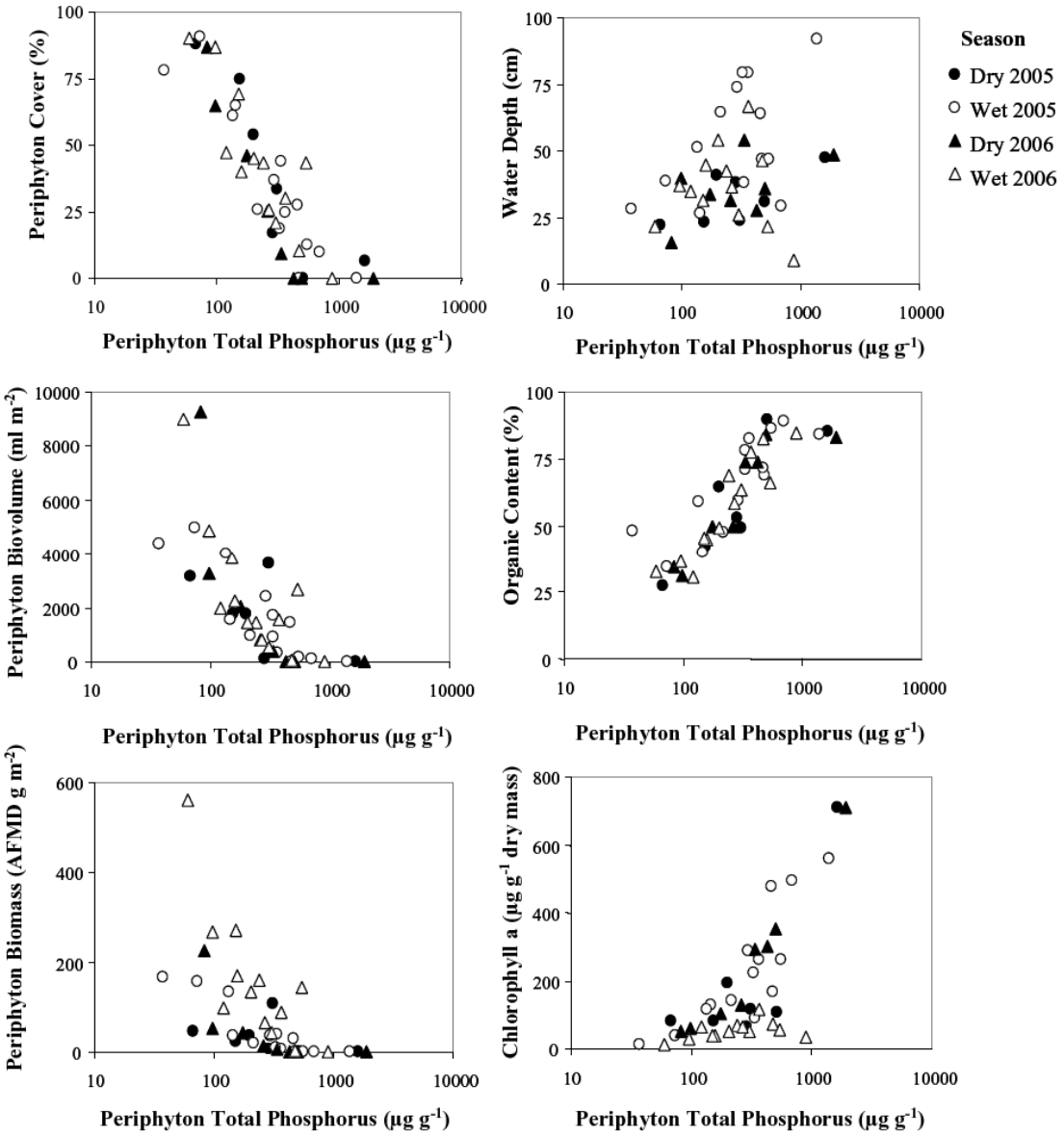

Figure 6. Non-metric Multidimensional Scaling ordination biplots of based on compositional similarity among all algae and diatoms-only. Site scores are color coded by site and vectors reflect the plane of maximum correlation for variables significantly associated with compositional similarity.

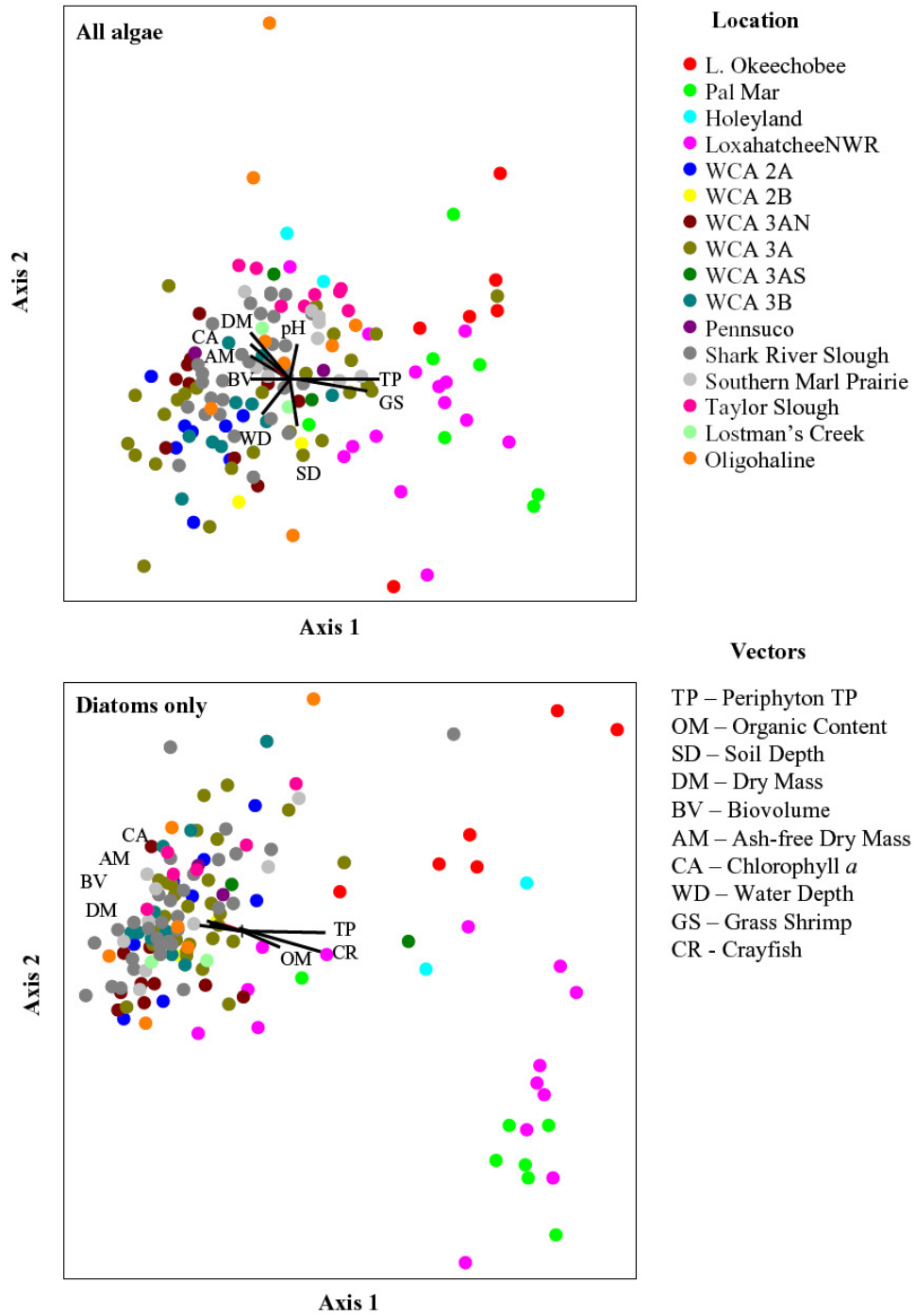

Figure 7. Relationships of periphyton dry mass, organic content, water depth and total phorphorus content to relative abundance of cyanophytes, chlorophytes and diatoms inhabiting the periphyton.

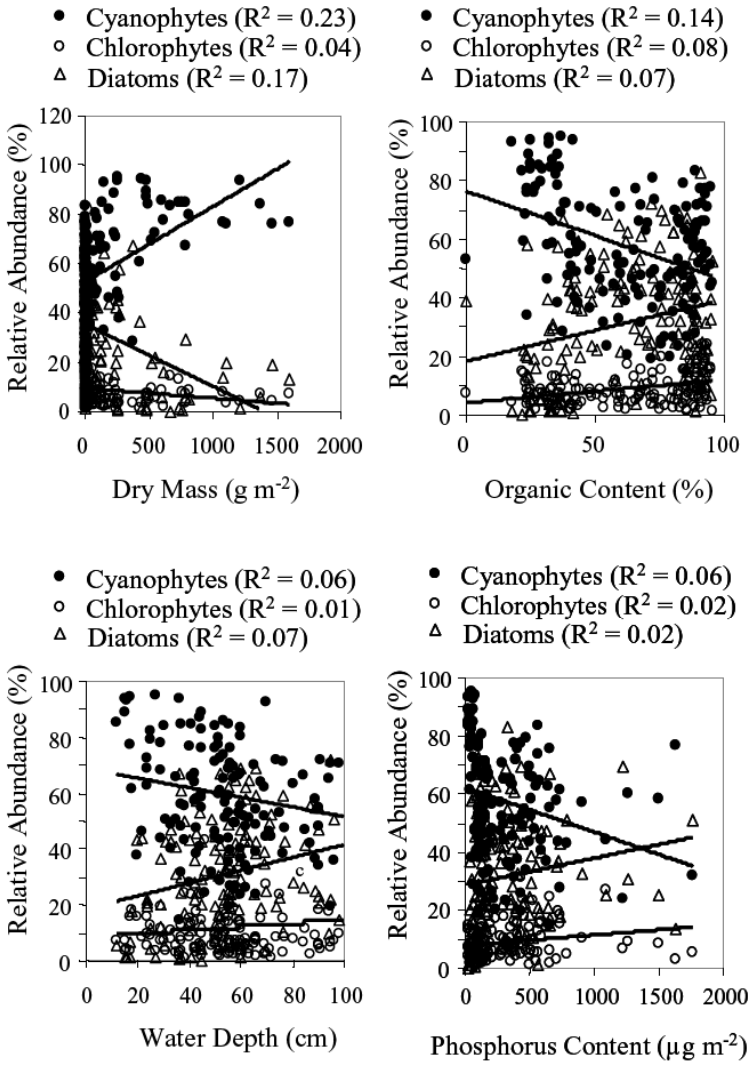

Figure 8. Relationships of periphyton dry mass and organic content to the abundance of different consumer groups among sites in the Fall 2005 survey.

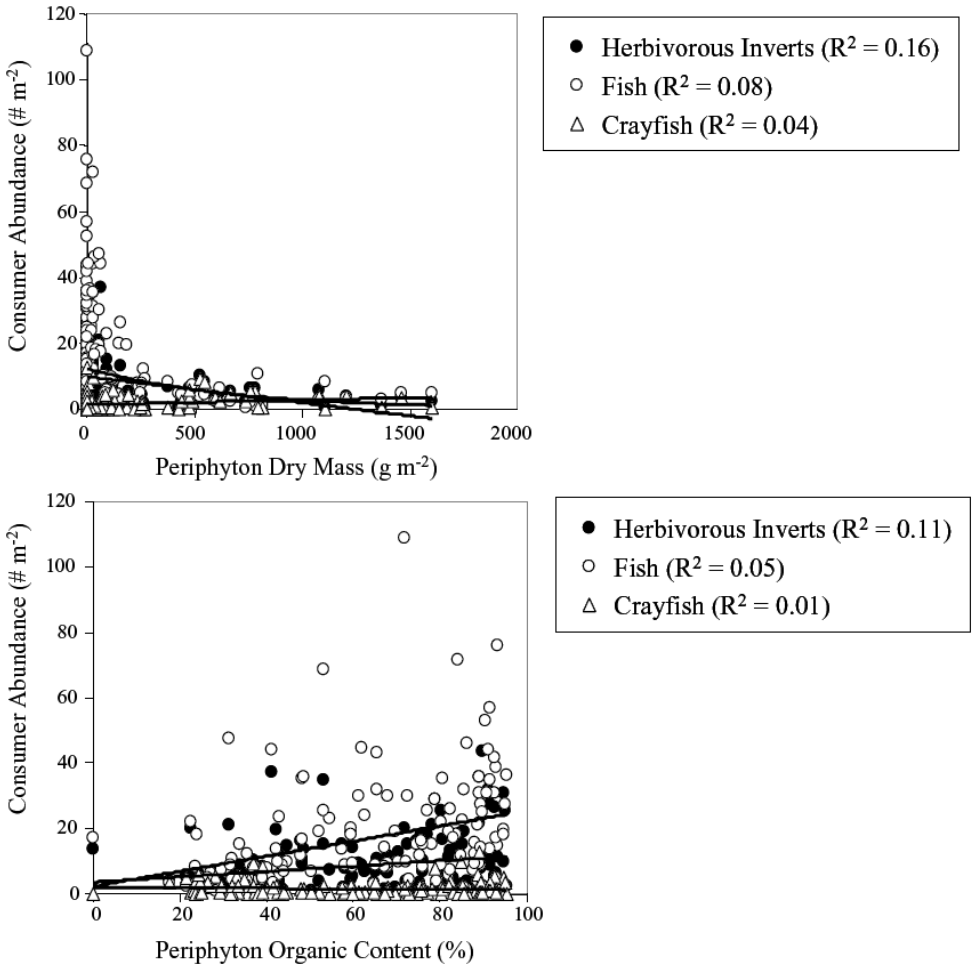

Figure 9. Relationships of the abundance of different algal groups (filamentous cyanobacteria, desmid algae and diatoms) to the abundance of consumers (grass shrimp, crayfish, herbivorous invertebrates and fish) among sites in the Fall 2005 survey.

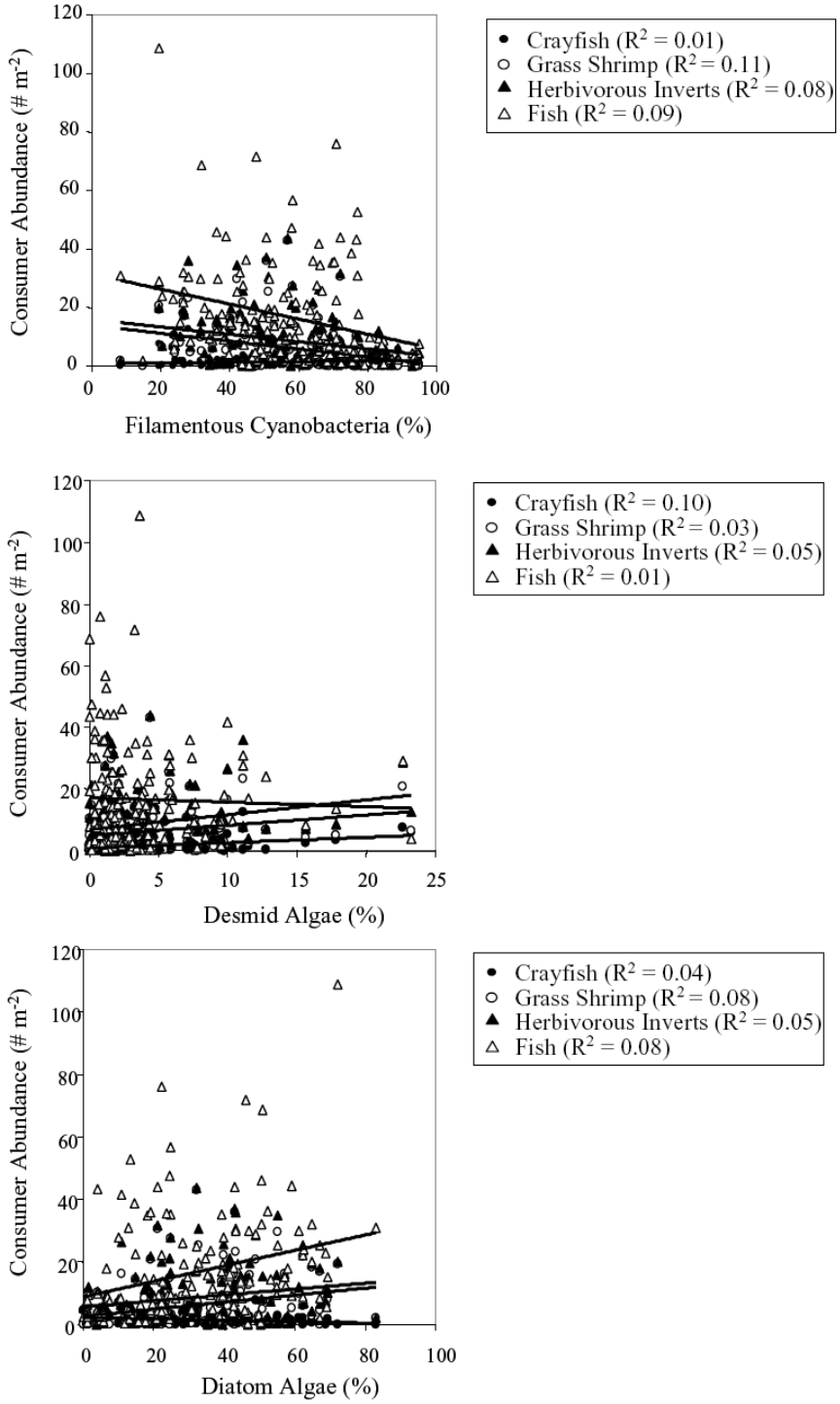

Figure 10. Periphyton data are summarized using target stoplight colors to illustrate how the performance measures relate to stoplight colors by location.

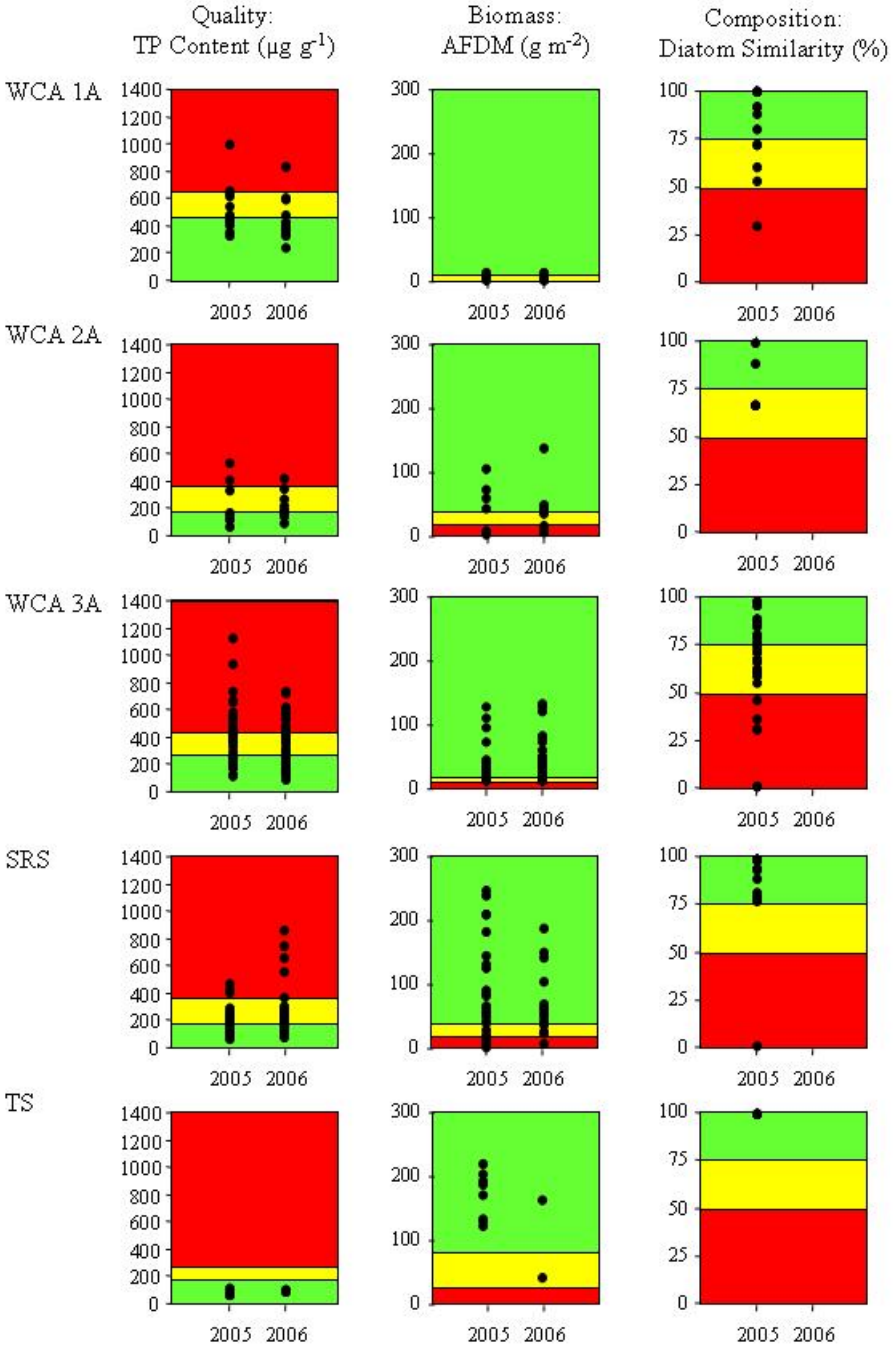
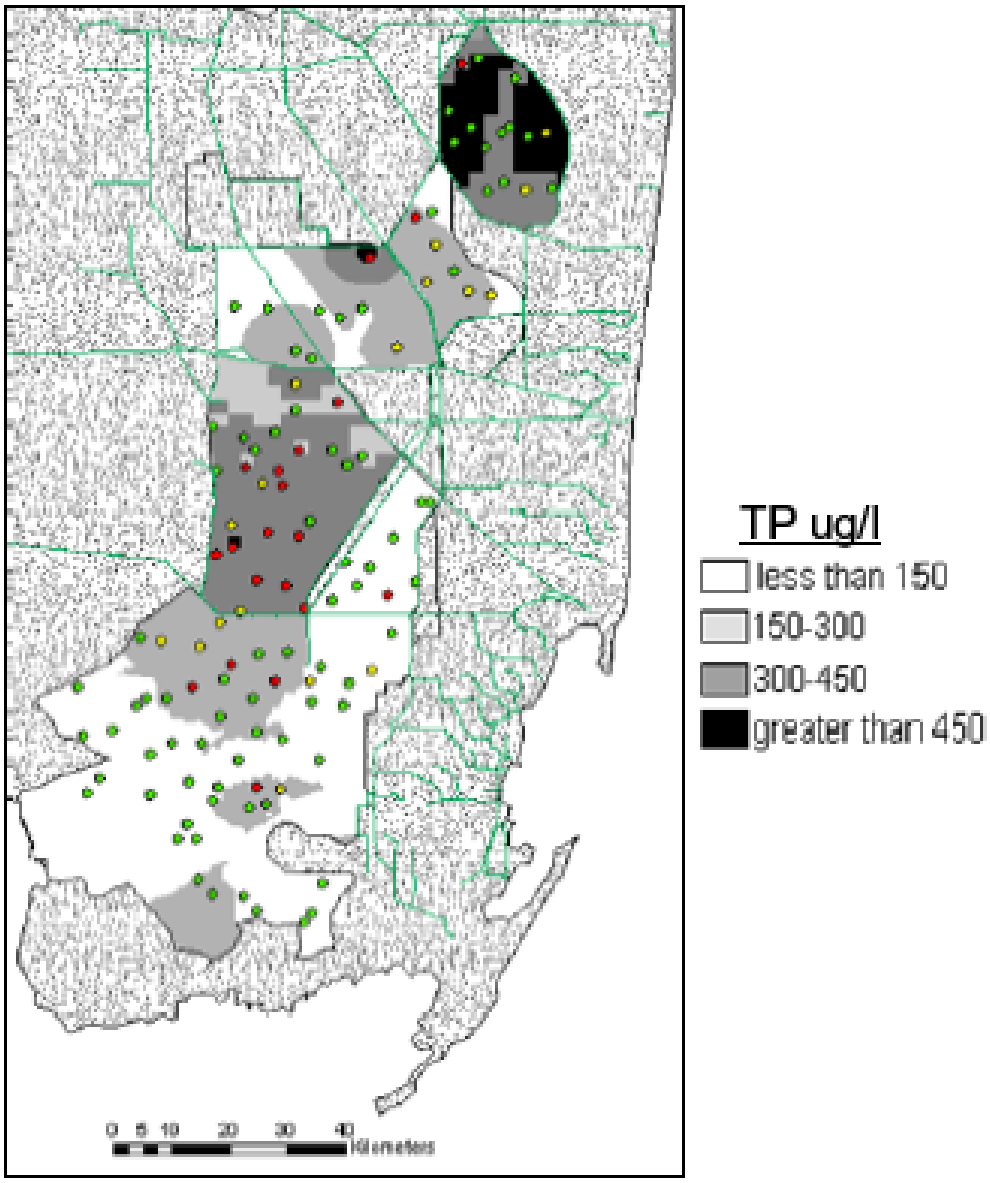
Figure 11. Map showing periphyton performance by area using stoplight coded circles.