LOXAHATCHEE RIVER WATER QUALITY AND BIOLOGICAL MONITORING

TASK 2: FINAL REPORT
ASSESSMENT OF 2007-2008 LOXAHATCHEE RIVER WATER QUALITY

In Partial Fulfillment of Agreement No. 4600001281

For the Period

October 2007 through September 2008

Respectfully Submitted by

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Director of Water Resources
Loxahatchee River District

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Introduction

Since 1971 the Loxahatchee River District (LRD) has been fulfilling its mission to preserve and protect the Loxahatchee River through an innovative wastewater treatment and reuse program and an active water quality monitoring program. LRD staff have monitored water quality in the surface waters of the Loxahatchee River and associated waters (see Figure 1) in an effort to document the condition and ecological health of the river and to determine the location and extent of water quality issues that need to be addressed. Over these past 35 years, the Loxahatchee River District has contributed significantly to the understanding of the ecology of this river. While numerous reports have been written regarding the Loxahatchee River, perhaps none are as timely and as comprehensive as the recently published *Restoration Plan for the Northwest Fork of the Loxahatchee River* (SFWMD 2006). This document characterizes the watershed, discusses various restoration alternatives, and identifies the preferred restoration flow scenario. In particular, Table 10-1 of the restoration plan includes the water quality targets for the marine (salinity >30 ppt), polyhaline (salinity 18 – 30 ppt), mesohaline (salinity 5 – 18 ppt), wild and scenic (salinity <5 ppt), and freshwater tributary (salinity <5 ppt) zones of the Loxahatchee River. These water quality targets (i.e., non-degradation standards) were established by LRD and SFWMD scientists using bi-monthly water quality data collected by LRD over the five year period 1998-2002.

Staff from the Loxahatchee River District's Wildpine Ecological Laboratory continue to collect water quality samples for nearly 30 parameters at approximately 35 sites located in the Loxahatchee River, its major tributaries, and associated waters (Figure 1). Approximately 25 sites are sampled bi-monthly (every other month), while 10 sites are sampled every month. This water quality monitoring program, entitled RiverKeeper, was developed to identify long-term trends, and assess long-term compliance with the interim water quality targets. Furthermore, on-going results from our water quality monitoring program will be used to establish baseline conditions prior to modification of freshwater inflows resulting from the Comprehensive Everglades Restoration Project and the Northwest Fork Restoration Plan (CERP 2001; SFWMD 2006).

The purpose of this report is to provide a simplified characterization and overview of the water quality conditions in Loxahatchee River over the previous year (October 2007 – September 2008). Water quality conditions during these intervals are specifically compared to the established water quality targets.

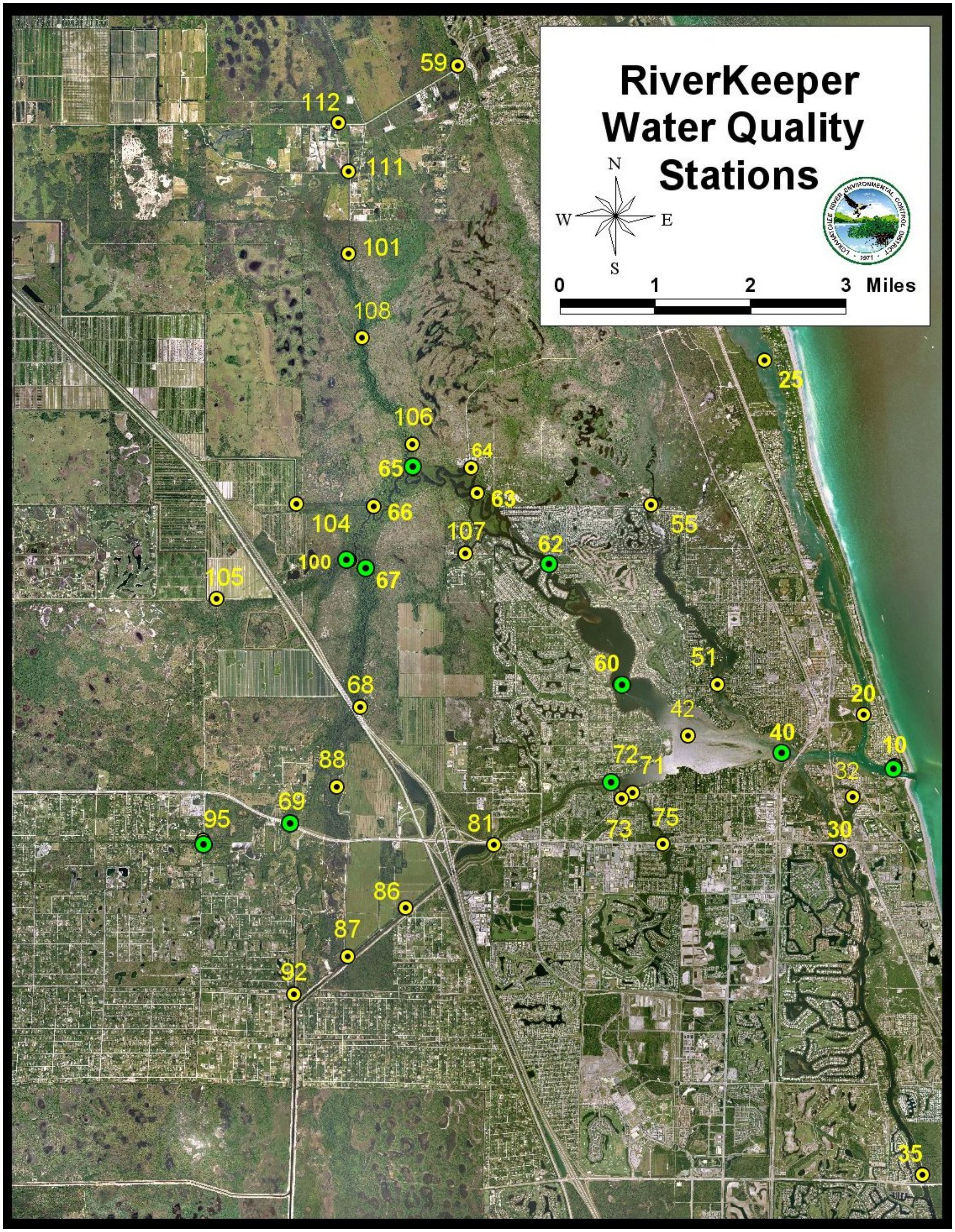


Figure 1. Loxahatchee River District's water quality monitoring stations in the Loxahatchee River and associated waters. During the period October 2007 through September 2008 green sites were sampled every month, while yellow sites were sampled every other month.

Study Area

The Loxahatchee River estuary encompasses approximately 400 ha and drains a watershed of approximately 700 km^2 located in northeastern Palm Beach County and southeastern Martin County, Florida, USA. Freshwater discharges into the estuary from the North Fork, the Northwest Fork, and the Southwest Fork of the Loxahatchee River. The hydrology of the basin has been substantially altered by flood control efforts since the 1950s. Historically (pre-1950), most surface water runoff reaching the estuary originated in the Loxahatchee and Hungryland Sloughs and flowed gradually to the Northwest Fork. In the 1930s the Lainhart Dam, a small fixed-weir dam, was constructed in the Northwest Fork at river mile 14.5 to reduce "over" drainage of upstream reaches of the Northwest Fork during the dry season. In 1958 a major canal (C-18) and flood control structure (S-46) were constructed to divert flows from the Northwest Fork to the Southwest Fork, which increased the intensity and decreased the duration of storm-related discharge to the estuary. Furthermore, since 1947 Jupiter inlet, the eastern link to the ocean, has been kept permanently open through ongoing dredging projects, which increased saltwater intrusion into the primarily freshwater Northwest Fork. Ongoing restoration efforts seek to increase base flows into the Northwest Fork, while not compromising the ecological integrity of downstream reaches (i.e., estuary) nor impairing valued ecosystem components of the estuary such as oysters and seagrasses (SFWMD 2006).

Materials and Methods

Water quality samples were collected every other month at stations identified in yellow and monthly at stations identified in green (Figure 1). At each station, physical water quality conditions (e.g., temperature, pH, conductivity, salinity, and dissolved oxygen) were evaluated using a Hydrolab multiprobe at the surface (0.3 m depth). At stations 60 through 66, the river reach most likely to be stratified, we also sampled at mid-depth and within 20 cm of the bottom.

Nutrient, bacteriological, chlorophyll a, turbidity, total suspended solids, and water color samples were processed following Standard Methods by the Loxahatchee River District's Wildpine Laboratory, which was certified under the National Environmental Laboratory Accreditation Program. Photosynthetically active radiation (PAR) was assessed by taking 3 replicates of PAR using 3 LI-COR spherical sensors (4π) simultaneously located at 20 cm, 50 cm, and 100 cm below the water surface.

Table 1. Spatial coordinates, in decimal degrees, of RiverKeeper water quality sampling sites.

Station	Latitude	Longitude	Station	Latitude	Longitude
10	26.945337639	-80.073825550	71	26.941606129	-80.118191758
20	26.953155294	-80.079008208	72	26.943294866	-80.121860971
25	27.007173848	-80.095378275	73	26.940722831	-80.120174373
30	26.932570076	-80.083156281	75	26.933683722	-80.113125006
32	26.940644699	-80.080911837	81	26.933736107	-80.141795559
35	26.883161038	-80.069530134	86	26.924279101	-80.156861591
40	26.947386072	-80.092820038	87	26.916923607	-80.166729831
42	26.950239941	-80.108793911	88	26.942755589	-80.168373690
51	26.957959120	-80.103746020	92	26.911314725	-80.175888274
55	26.985301640	-80.114836422	95	26.934725440	-80.191174483
59	27.052419955	-80.147136065	100	26.977266552	-80.165974449
60	26.958044581	-80.120270262	101	27.023802186	-80.165826223
62	26.976287767	-80.131916059	104	26.985785966	-80.175007368
63	26.987305421	-80.144271885	105	26.971485286	-80.188653132
64	26.991109025	-80.145302861	106	26.994781472	-80.155140725
65	26.991137909	-80.155045620	107	26.978191835	-80.146332086
66	26.985330292	-80.161806702	108	27.011121488	-80.163694292
67	26.976002794	-80.163348247	111	27.036378054	-80.165660602
68	26.954927363	-80.164359272	112	27.043773986	-80.167337373
69	26.937309460	-80.176155231		*Datum = WGS 1984*	

We used a ‘stoplight’ approach to provide a simplified, integrated assessment of observed water quality conditions relative to target water quality values for each of the five river reaches: marine (stations 10, 20, 30), polyhaline (stations 51, 60, 72), mesohaline (stations 62, 63, 64), wild and scenic (stations 67, 68, 69), and freshwater tributaries (stations 81, 95, 100). Analytical results for each river reach were divided into three categories (red, yellow, and green), which can be interpreted similar to the colors in a traffic signal (See Appendix A for decision rules). Green indicates good or acceptable conditions – no degradation is occurring. Yellow indicates caution should be observed – degradation may or may not be occurring (i.e., there may be cause for concern). Red indicates degradation likely is occurring, and resource managers should stop and determine what actions might be employed to remedy the degradation in observed conditions.

One cautionary note must be addressed relative to comparing the results of the present study versus the target water quality values. Results presented herein were based on 12 months of sampling, while target water quality values were based on sampling over five years. Analysis of results from a longer sampling period should buffer extreme (either high or low) values, which would allow a more conservative assessment. Nonetheless, the present assessment represents a legitimate evaluation of ongoing water quality conditions in the watershed over the past year.

Results & Discussion

During the period October 2007 through September 2008 we collected and analyzed 383 water quality samples for approximately 25 parameters resulting in over 6,600 analytical results. When compared against the water quality targets, these results suggest there may be cause for concern for water quality in the Loxahatchee River for the period October 2007 through September 2008. The table below shows a simplified interpretation of water quality results for the distinct river reaches. The chart immediately suggests that the freshwater tributaries should be further assessed and may be among the best areas in which to conduct water quality improvement projects in the watershed. Similarly, chlorophyll *a* concentrations scored a 'code red' in the upstream and middle reaches of the river, suggesting impairment of the Northwest Fork (at least for this parameter). The marine segment showed the greatest overall health, based on a summary score of green. This downstream river reach is dominated by Atlantic Ocean water flowing in through the Jupiter Inlet.

Table 2. A 'stoplight' assessment of water quality among the five river reaches of the Loxahatchee River for the period October 2007 – September 2008.

Parameter	Marine	Polyhaline	Mesohaline	Wild & Scenic	Freshwater Tributaries
Total Suspended Solids	Green	Green	Green	Green	Yellow
Dissolved Oxygen	Green	Yellow	Green	Yellow	Yellow
Total Phosphorus	Green	Green	Green	Yellow	Yellow
Total Nitrogen	Green	Green	Green	Yellow	Yellow
Chlorophyll *a*	Yellow	Red	Red	Red	Yellow
Fecal Coliform Bacteria	Yellow	Yellow	Red	Green	Yellow
Summary	Green	Yellow	Yellow	Yellow	Yellow

In addition to the stoplight assessment, we present water quality results using box and whisker plots in order to compare data from the water quality target period (1998-2002) to the previous two years (2006-2007 and 2007-2008) (see Appendix B for plots for all parameters).

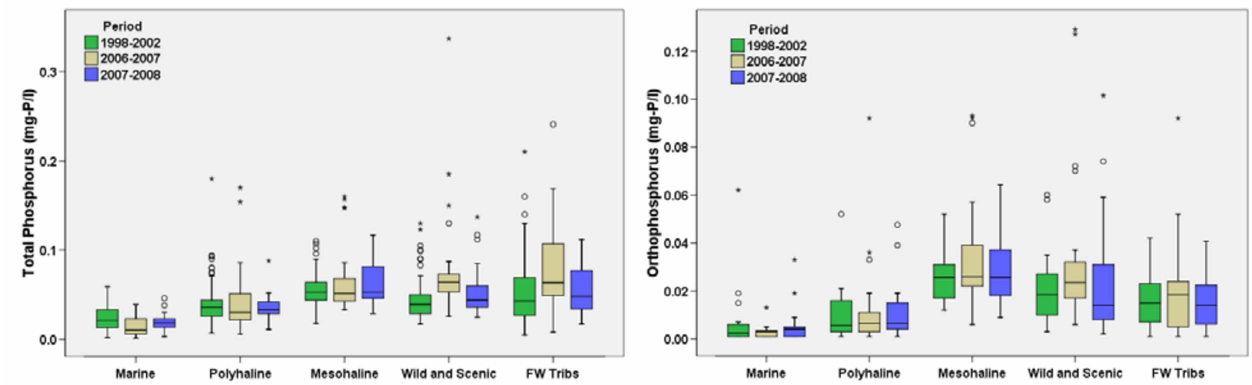


Figure 2. Total phosphorous and orthophosphorus concentrations in the five Loxahatchee River segments during the water quality target period (1998-2002), 2006-2007, and 2007-2008.

Figure 2 illustrates spatial and temporal changes in phosphorous concentrations among the five river segments (marine, polyhaline, mesohaline, wild and scenic, and freshwater tributaries). Total phosphorous and orthophosphorus (biologically available form) concentrations exhibited a relatively predictable spatial pattern with highest concentrations typically observed in the mesohaline reach. In the downstream reaches median phosphorous concentrations were quite comparable across the three time periods; however, in the wild and scenic and freshwater tributaries we recorded a slight increase in median phosphorus concentrations relative to the target period, though these values were lower than the values observed during 2006-2007.

Turbidity is typically low (less than 5 NTU) in the Loxahatchee River; however, some notable exceptions were observed during the 2006-2007 year (Figure 3). We saw a return to relatively normal turbidity conditions throughout much of the system during 2007-2008, though some exceptionally high turbidity values observed at station 95 (Jupiter Farms canal) drove the large amount of variability observed in the freshwater tributaries for the 2007-2008 year.

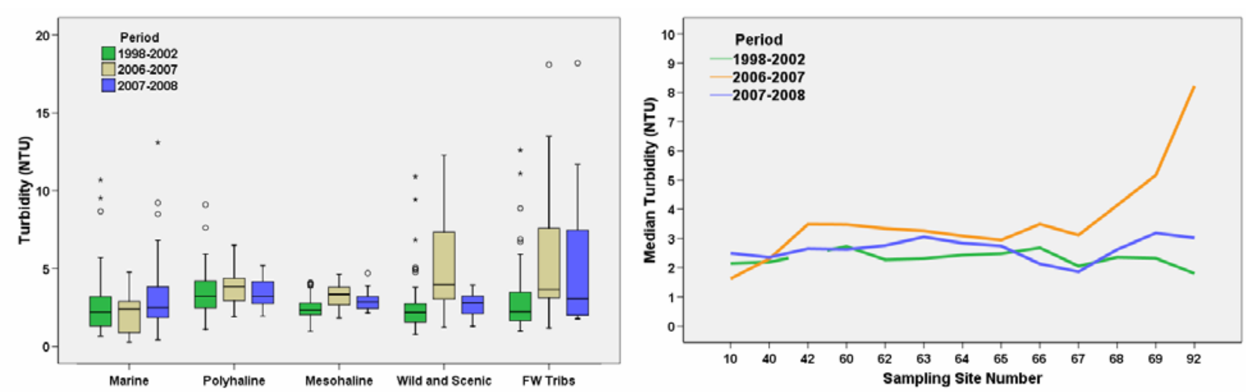


Figure 3. Turbidity (A) across the five Loxahatchee River segments, and (B) across key sampling sites [upstream (left) to downstream (right)] during the water quality target period (1998-2002), 2006-2007, and 2007-2008. Consult Figure 1 to determine sample sites locations.

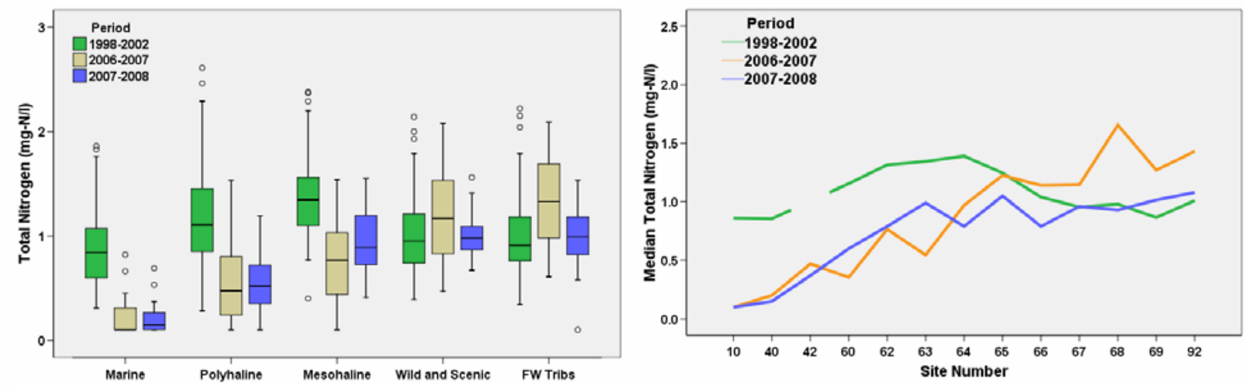


Figure 4. Total nitrogen (A) across the five Loxahatchee River segments, and (B) across key sampling sites [upstream (left) to downstream (right)] during the water quality target period (1998-2002), 2006-2007, and 2007-2008. Consult Figure 1 to determine sample sites locations.

Total nitrogen concentrations (Figure 4) exhibited contrasting patterns between upstream and downstream reaches of the river. The wild and scenic and freshwater tributary reaches, characterized by freshwater, exhibited elevated total nitrogen concentrations in 2006-2007 with a return to normal concentrations in 2007-2008. Downstream reaches (i.e., marine to mesohaline; stations 10 through 64), which are characterized by saltier water, were characterized by lower total nitrogen values for the last two years. This apparent trend in decreasing nitrogen concentrations at our marine sites is due to a change in our analytical technique in January 2005, and does not represent a real decrease in total nitrogen concentrations. This is methodological change is unfortunate, however, we are glad the analytical issue was identified and remedied.

During the 2007-2008 period, chlorophyll *a* concentrations were the largest cause for concern (see Table 1 and Figure 5). Chlorophyll *a* concentrations were noticeably higher in the middle reaches of the river. Presently, we are unsure of the proximate mechanism leading to observed increases in algae (chlorophyll *a*) concentrations at these stations.

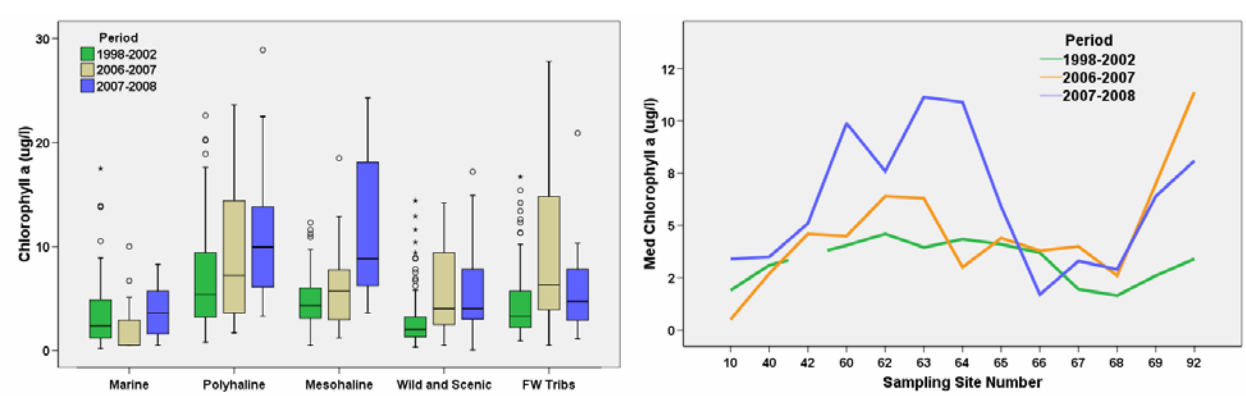


Figure 5. Chlorophyll *a* concentrations (A) across the five Loxahatchee River segments, and (B) across key sampling sites [upstream (left) to downstream (right)] during the water quality target period (1998-2002), 2006-2007, and 2007-2008. Consult Figure 1 to determine sample sites locations.

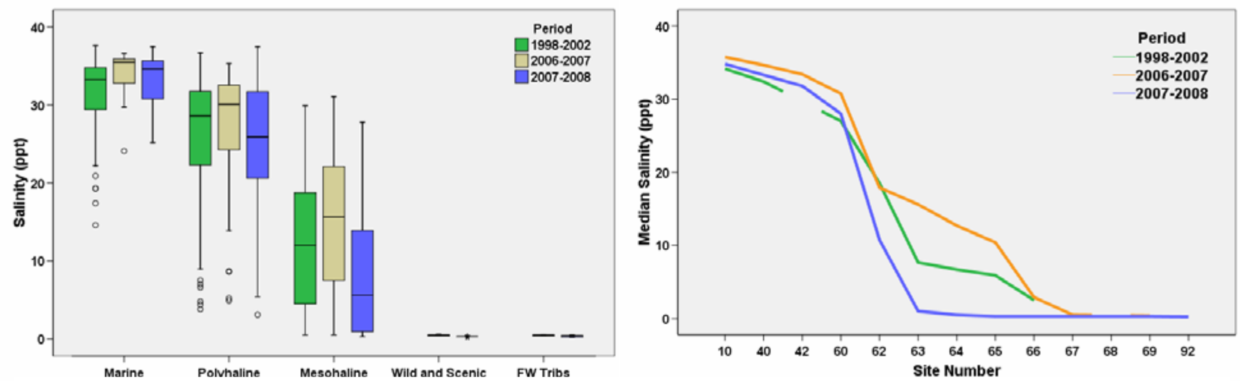


Figure 6. Salinity conditions (A) across the five Loxahatchee River segments, and (B) across key sampling sites [upstream (left) to downstream (right)] during the water quality target period (1998-2002), 2006-2007, and 2007-2008. Consult Figure 1 to determine sample sites locations.

Salinity values were lower than normal at the mesohaline sites (63, 64, and 65) during the 2007-2008 period, though they were appreciably higher at these same sites during 2006-2007. Freshwater discharge data from Lainhart Dam (Figure 7) show the 2006-2007 period was much drier than normal, which resulted in very low flows into the Northwest Fork. In 2007-2008 tropical storms delivered significant rainfall events which resulted in higher flows and fresher conditions at the mesohaline sites. Such data demonstrate how quickly this region can switch from too little to too much rainfall and associated stormwater runoff.

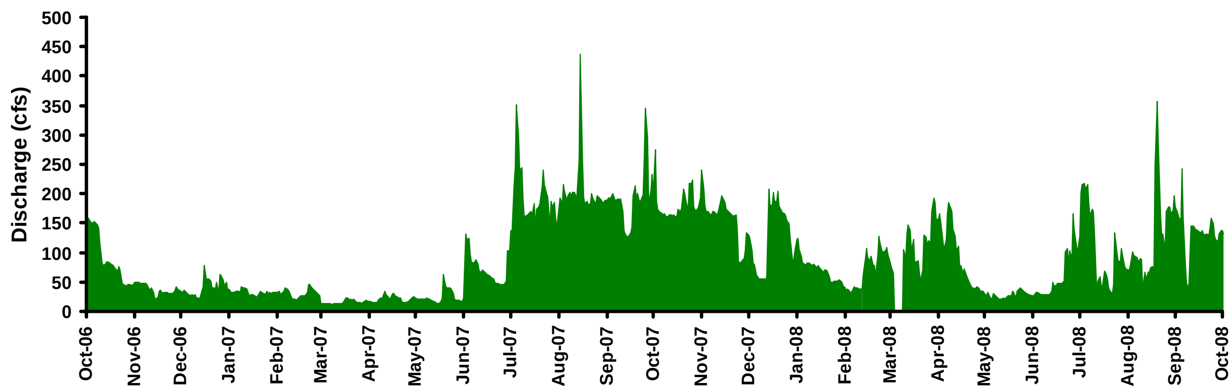


Figure 7. Freshwater discharged into the Northwest Fork of the Loxahatchee River, as measured at Lainhart Dam, was below average for the period 2006-2007, and returned to more normal levels during the 2007-2008 period.

In conclusion, water quality in the Loxahatchee River suggests there may be some cause for concern (i.e., the summary stoplight condition was yellow). While several parameters, especially for the downstream reaches, were equal to or better than target water quality conditions, the majority of parameters assessed were marginally higher than target conditions. In particular, the freshwater tributaries exhibited the worst general condition and future enhancement and restoration projects should be targeted in these areas.

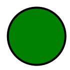
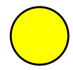
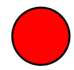
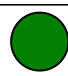
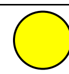
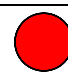
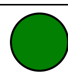
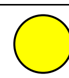
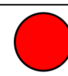
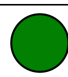
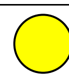
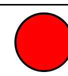
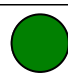
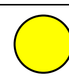
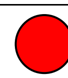
We believe the RiverKeeper water quality monitoring program is an excellent and efficient approach to monitor water quality in the Loxahatchee River watershed. Because of LRD's long standing commitment to assess water quality in the Loxahatchee River watershed, we have an excellent historical record against which present water quality conditions can be compared. As restoration efforts continue to move forward in the watershed, we will continue to assess current water quality conditions and compare them against the established target conditions (1998-2002) and the pre-restoration conditions, thereby providing a comprehensive measure of project success. Such across-time comparisons are invaluable when trying to adaptively manage our valuable resources. Finally, it should be noted that while much work has been done in the Loxahatchee River Watershed (e.g., the numerous LRPI projects) there remain serious water quality issues that must be addressed.

Literature Cited

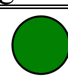
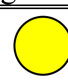
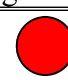
CERP (Comprehensive Everglades Restoration Plan). 2001. Baseline Report for the Comprehensive Everglades Restoration Plan. South Florida Water Management District, West Palm Beach, Florida.

SFWMD. 2006. Restoration Plan for the Northwest Fork of the Loxahatchee River. South Florida Water Management District, West Palm Beach, Florida.

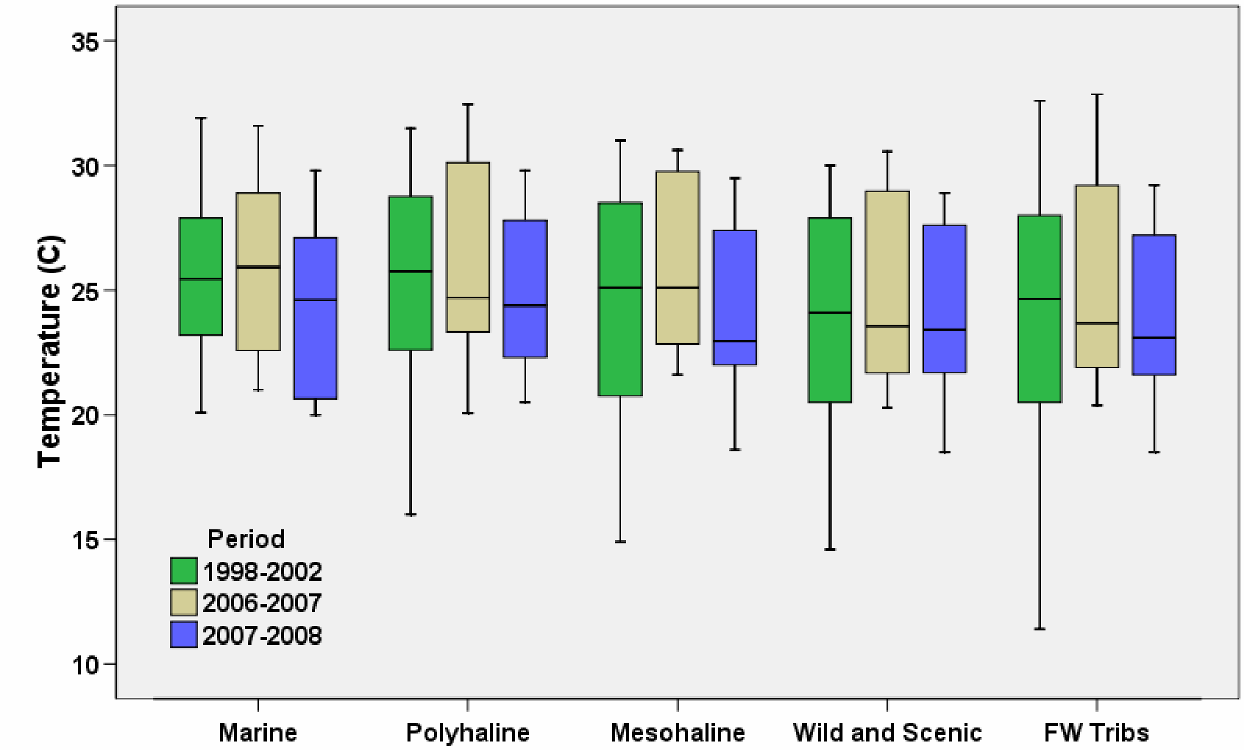
Appendix A. Decision rules used in the 'stoplight' assessment. Because we assumed the observed conditions during the target period represent non-degradation conditions, we therefore scored conditions equal to or better than those conditions as green (good). Conditions slightly worse than the target conditions (i.e., between the 50th and 75th percentile) were scored yellow (caution). Observed conditions significantly worse than the target conditions (i.e., falling outside of the 75th percentile) were scored as red (cause for concern). In order to address the natural variability observed in the system, assessment was based on the median value for the parameter and period being assessed.

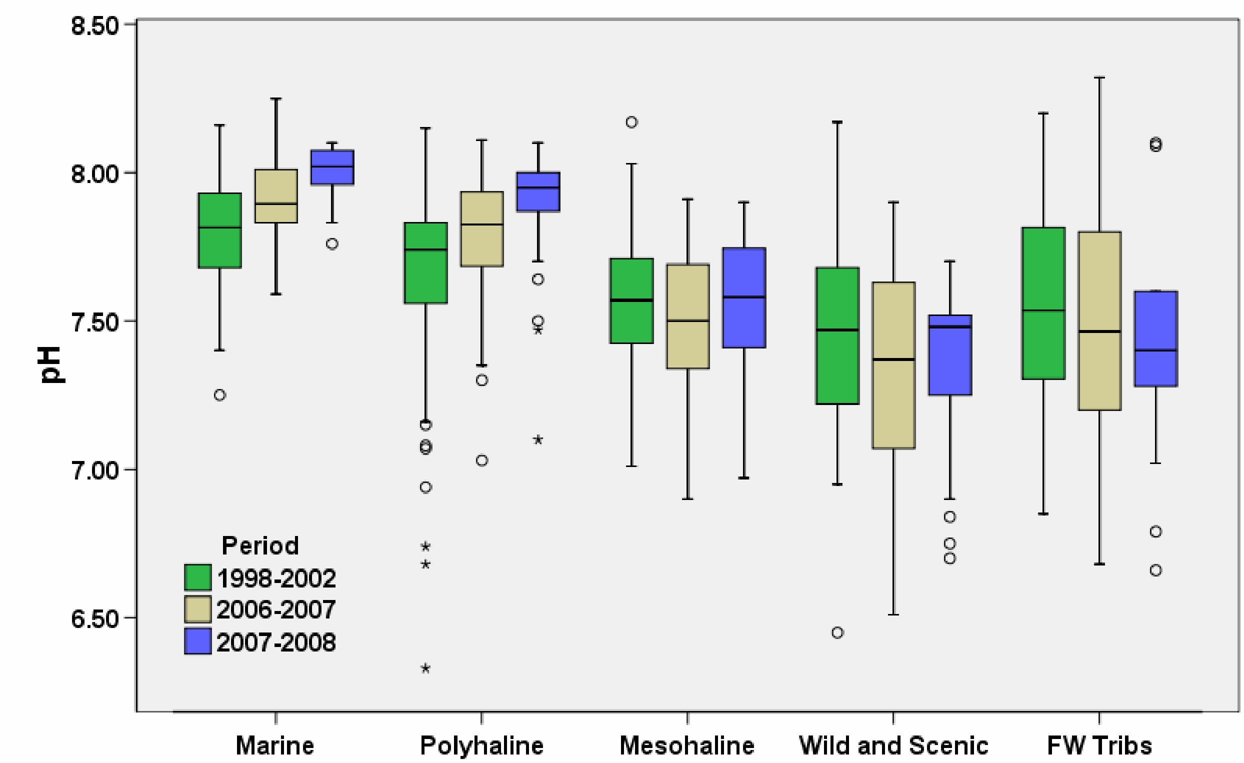
Parameter	$\leq$ Median Target Value	> Median Target Value	>75th Percentile Target Value
Total Suspended Solids			
Total Phosphorus			
Total Nitrogen			
Chlorophyll *a*			
Fecal Coliform Bacteria			

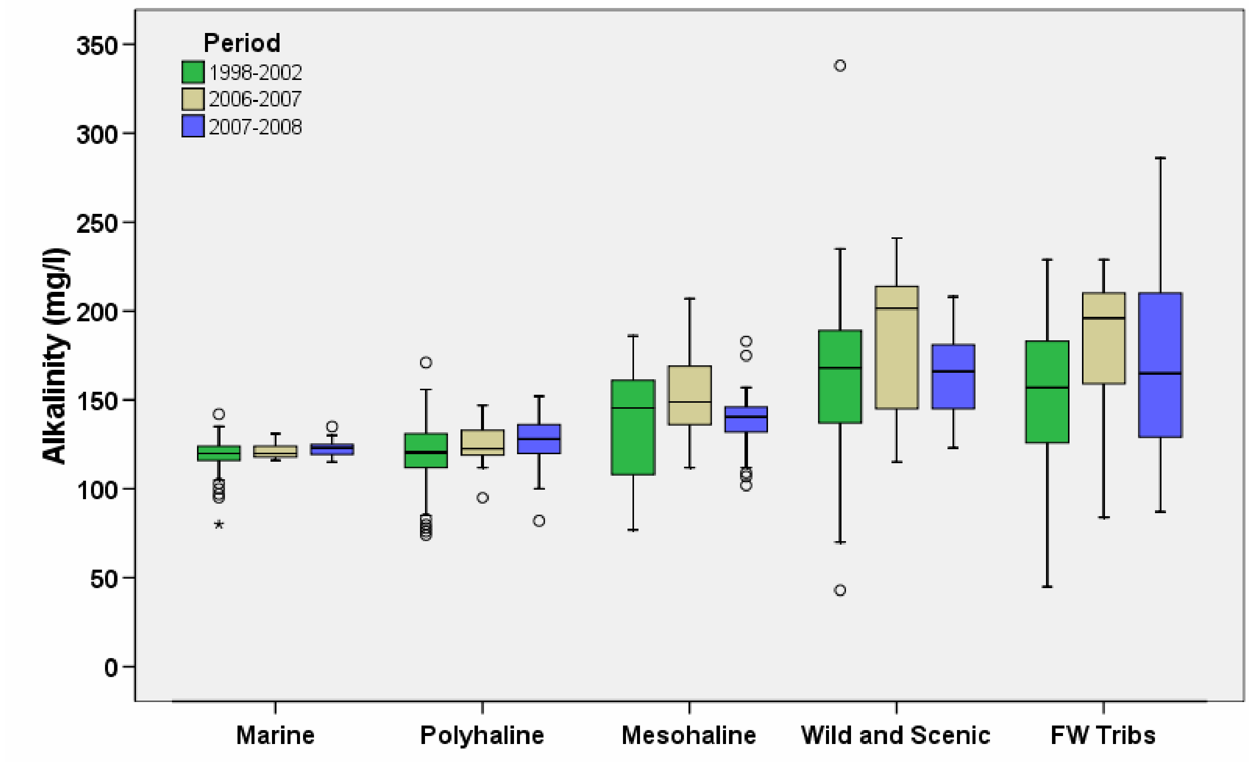
Because higher dissolved oxygen concentrations are more desirable, the thresholds were reversed as shown below.

Parameter	$\geq$ Median Target Value	< Median Target Value	< 25th Percentile Target Value
Dissolved Oxygen			

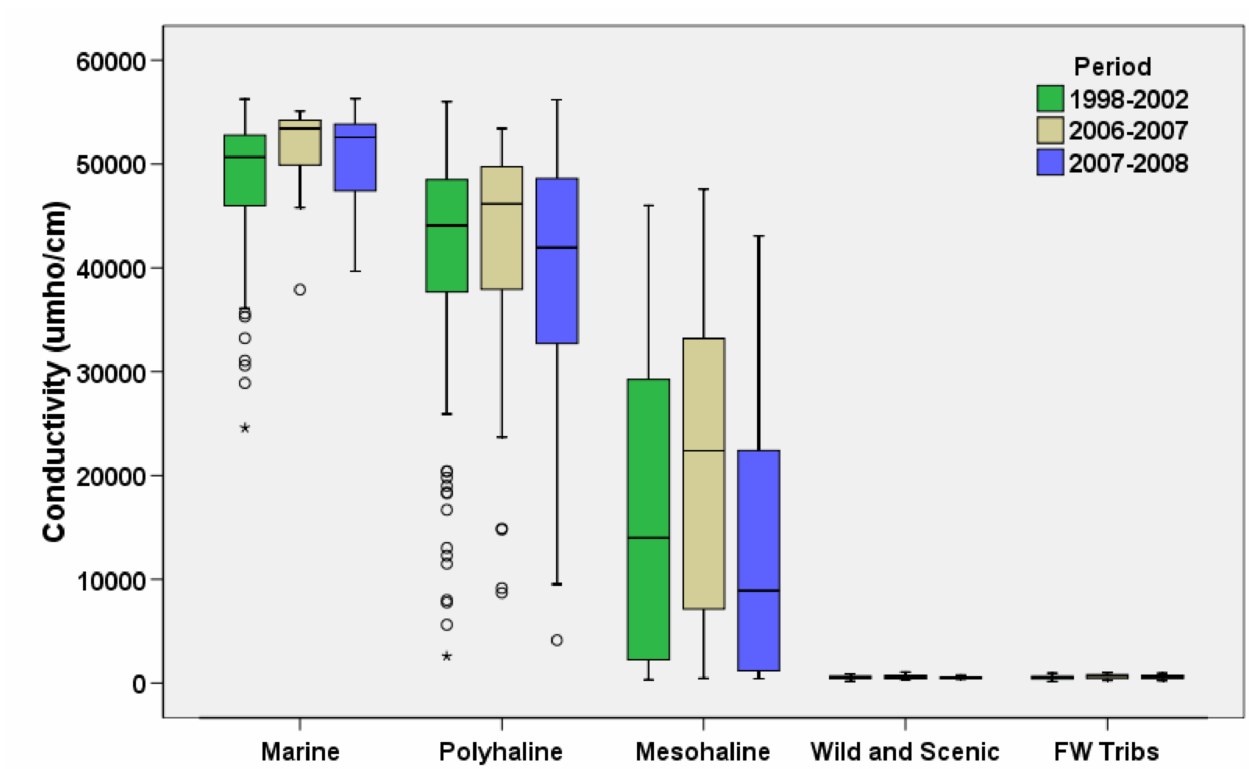
Appendix B. Box and whisker plots of Loxahatchee River District's RiverKeeper data for the period October 2007 through September 2008. See Figure 1 for a map of sample site locations.



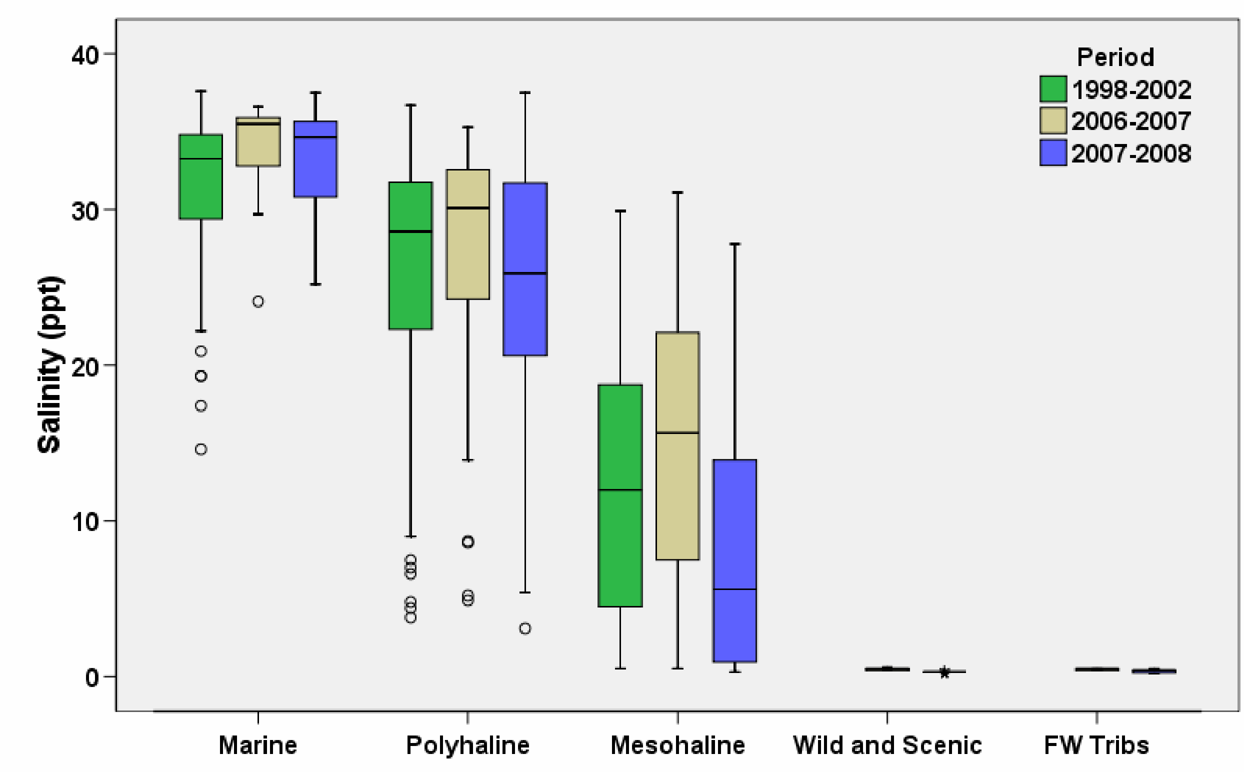


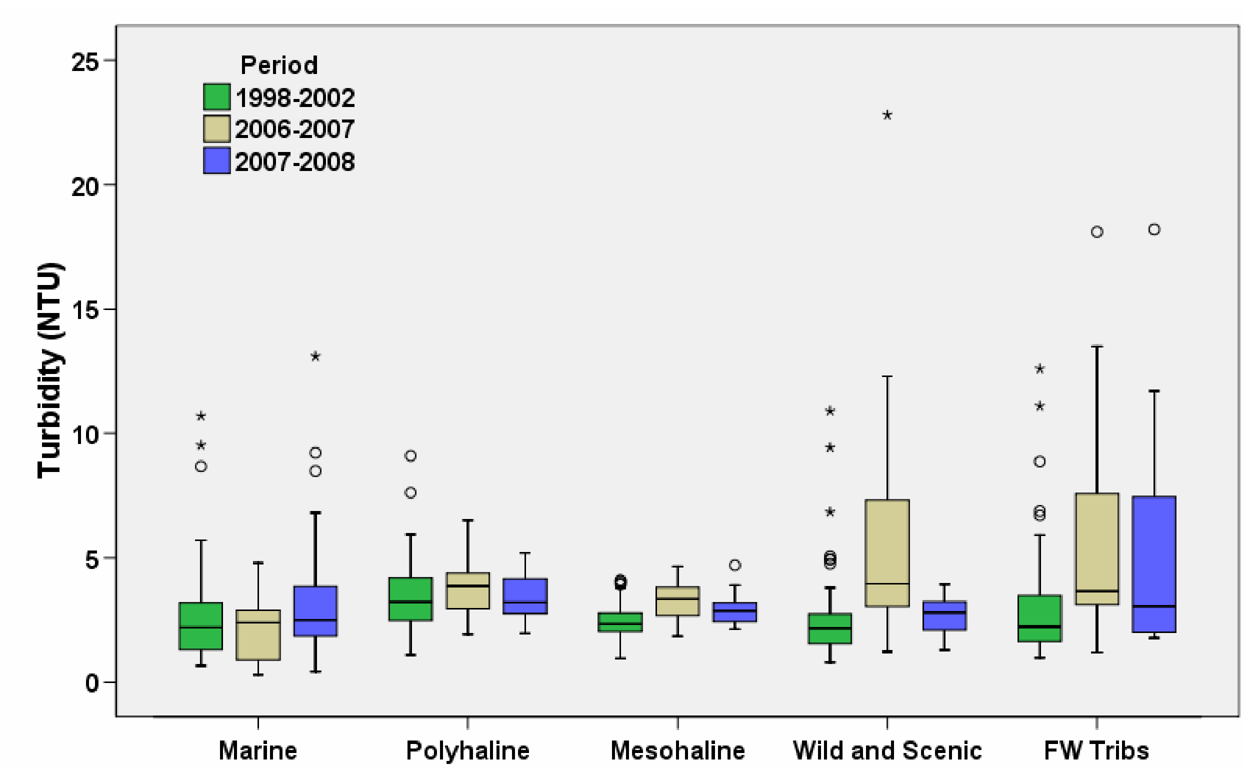


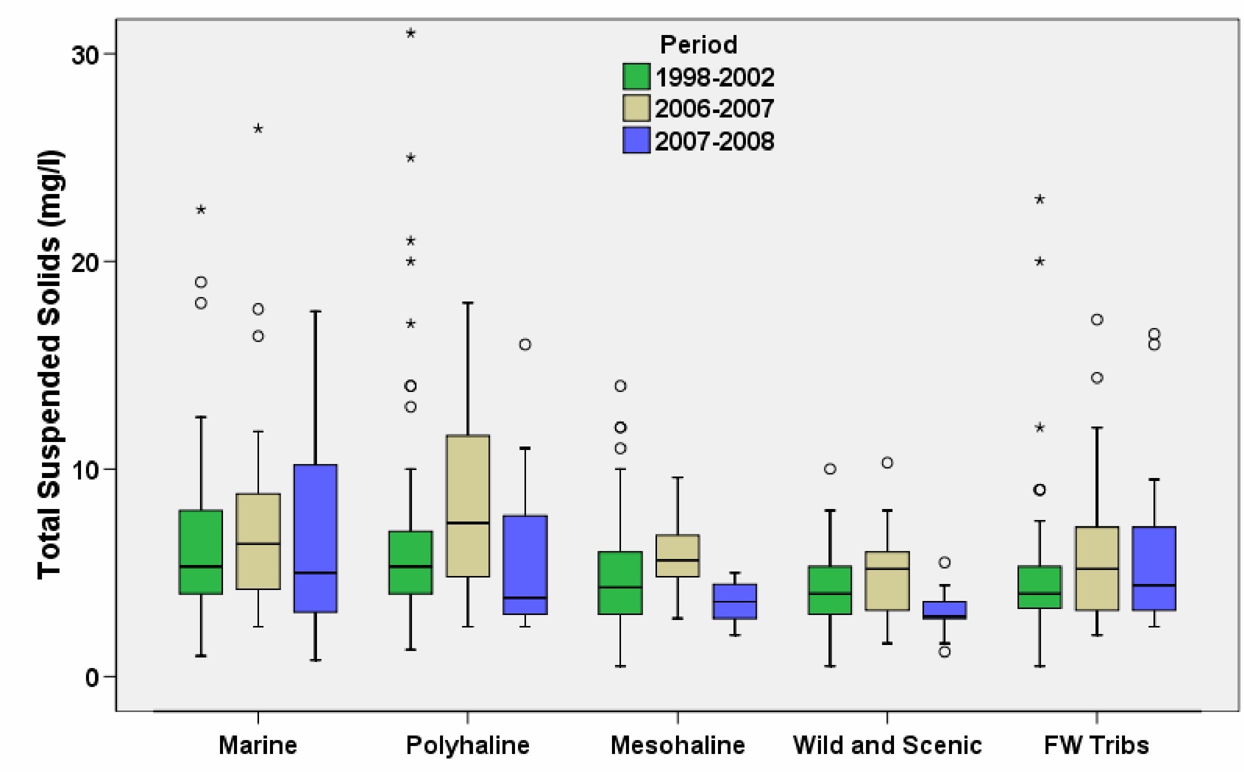
Period
1998-2002
2006-2007
2007-2008
Alkalinity (mg/l)
350
300
250
200
150
100
50
0
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs

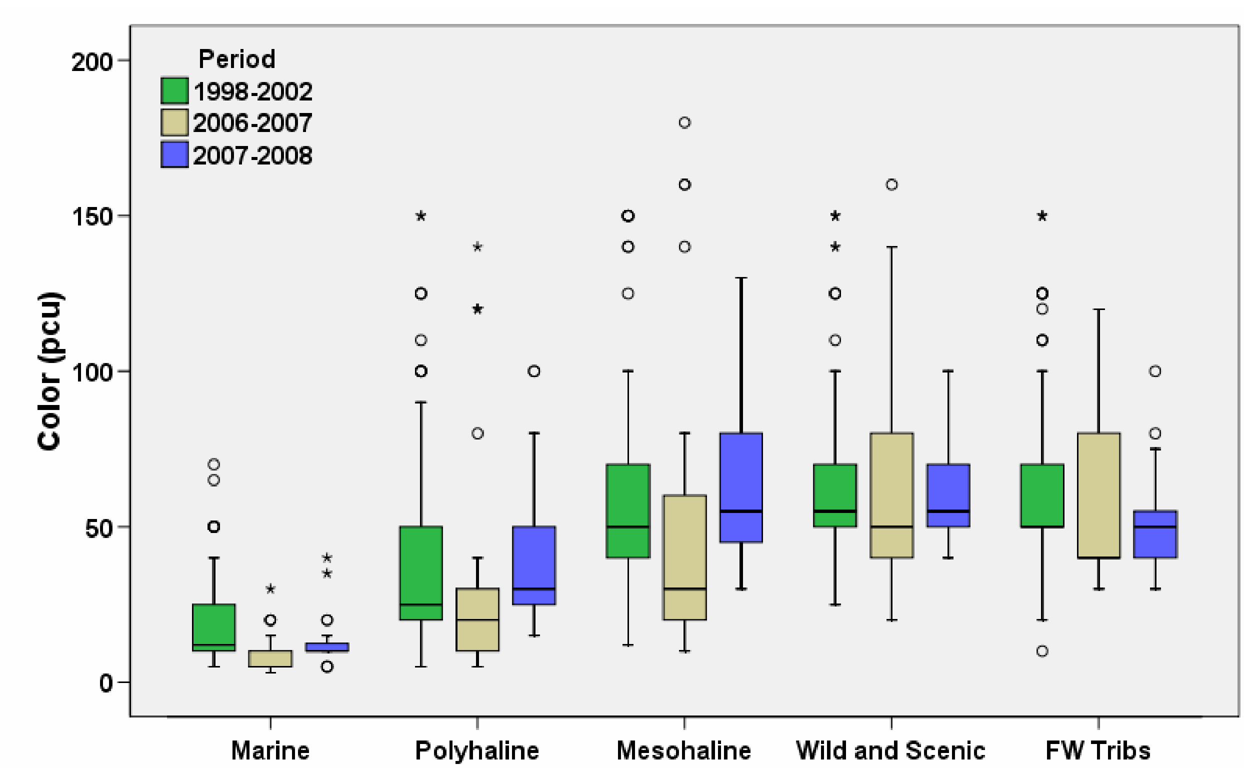


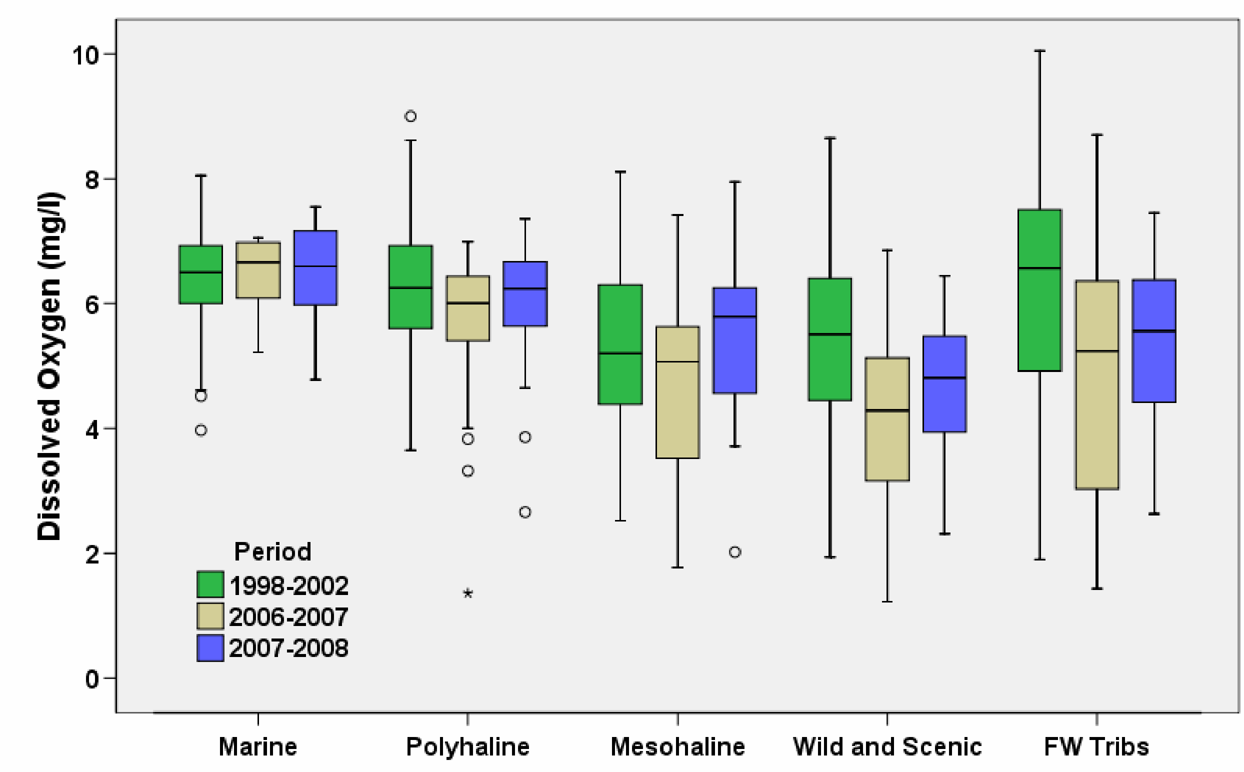
Period
1998-2002
2006-2007
2007-2008
Conductivity (umho/cm)
60000
50000
40000
30000
20000
10000
0
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs

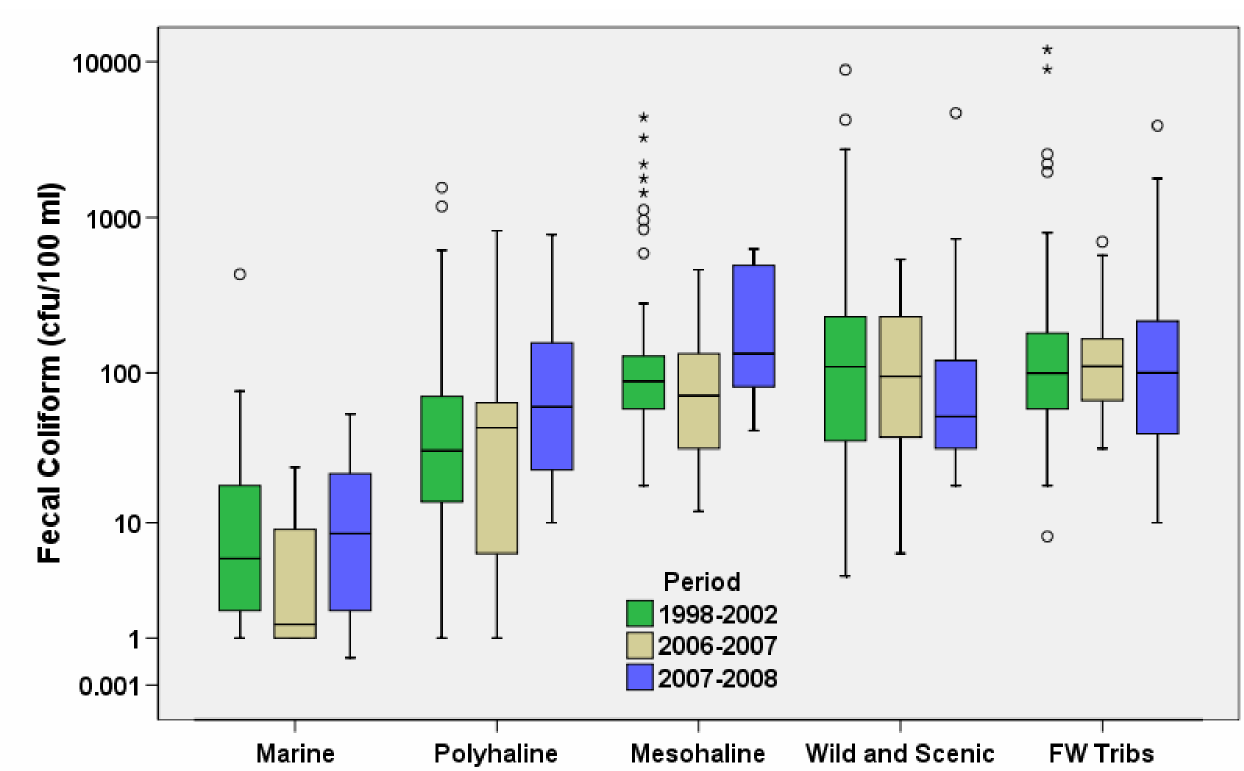

Period
1998-2002
2006-2007
2007-2008
Salinity (ppt)
40
30
20
10
0
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs

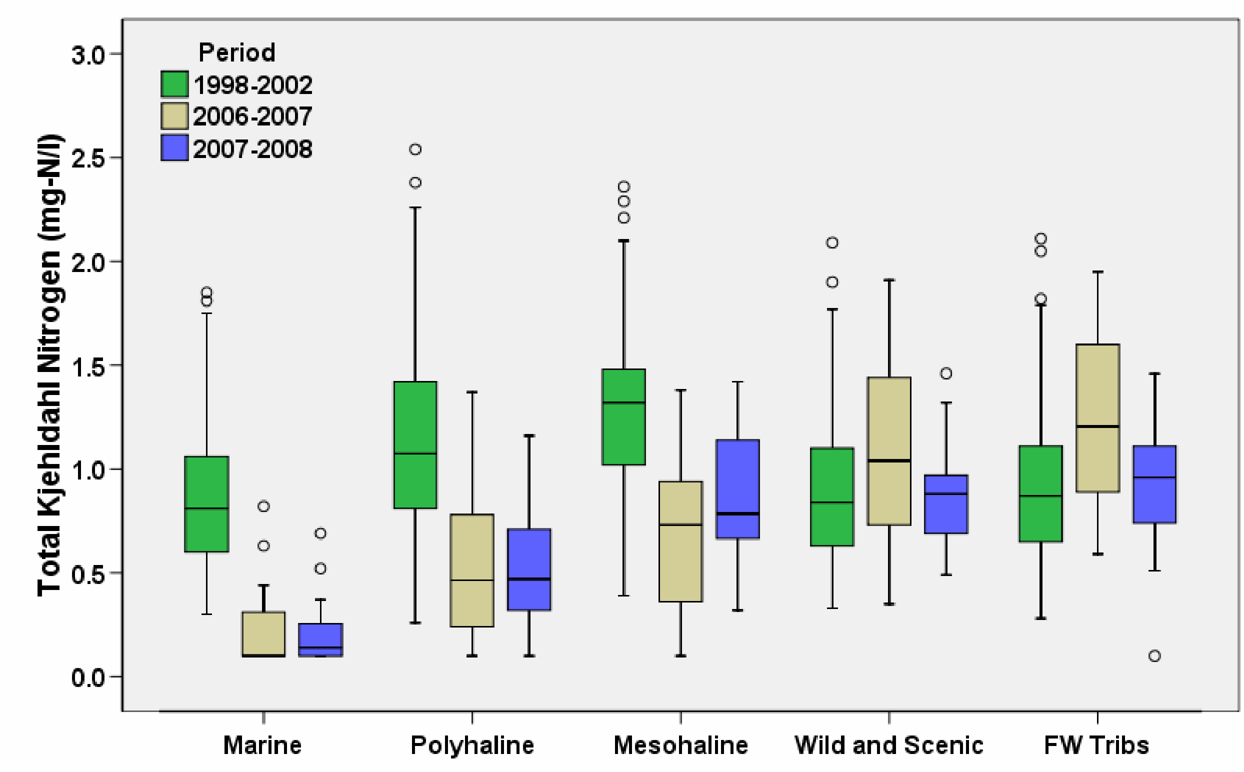

Period
1998-2002
2006-2007
2007-2008
Turbidity (NTU)
25
20
15
10
5
0
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs

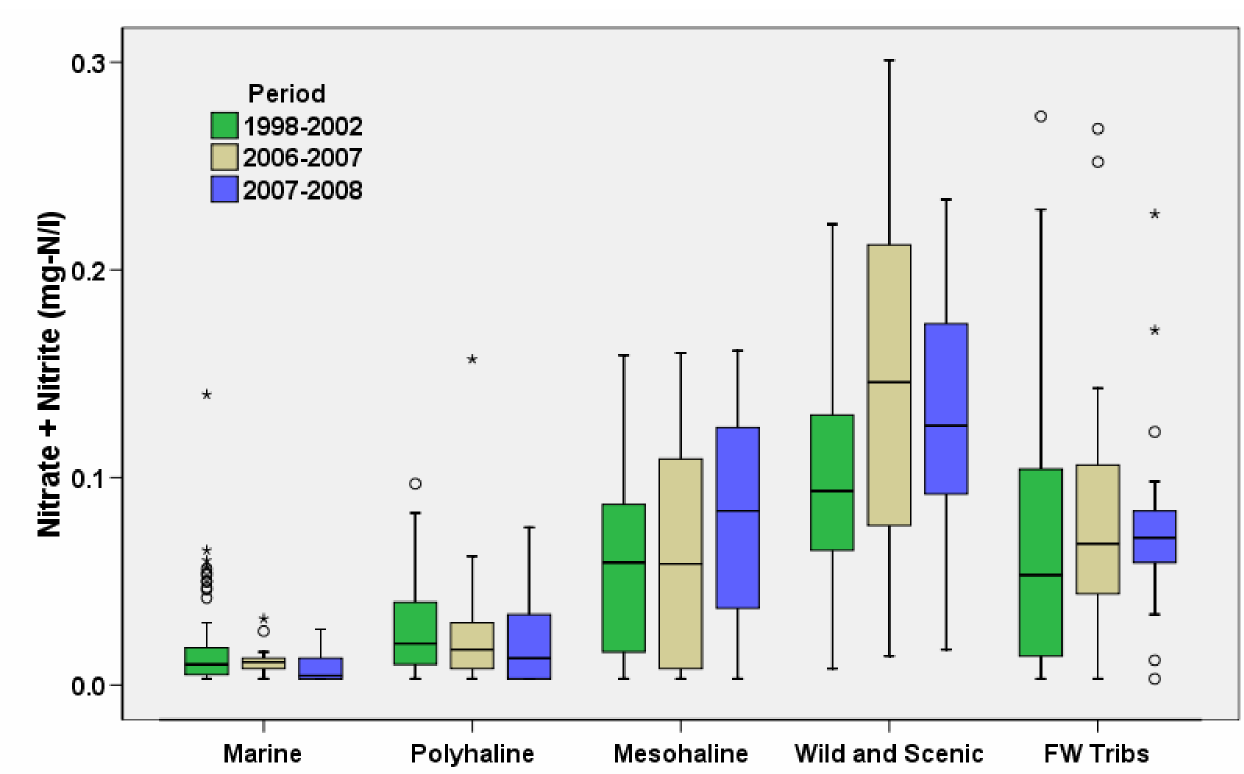

Period
1998-2002
2006-2007
2007-2008
Total Suspended Solids (mg/l)
0
10
20
30
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs

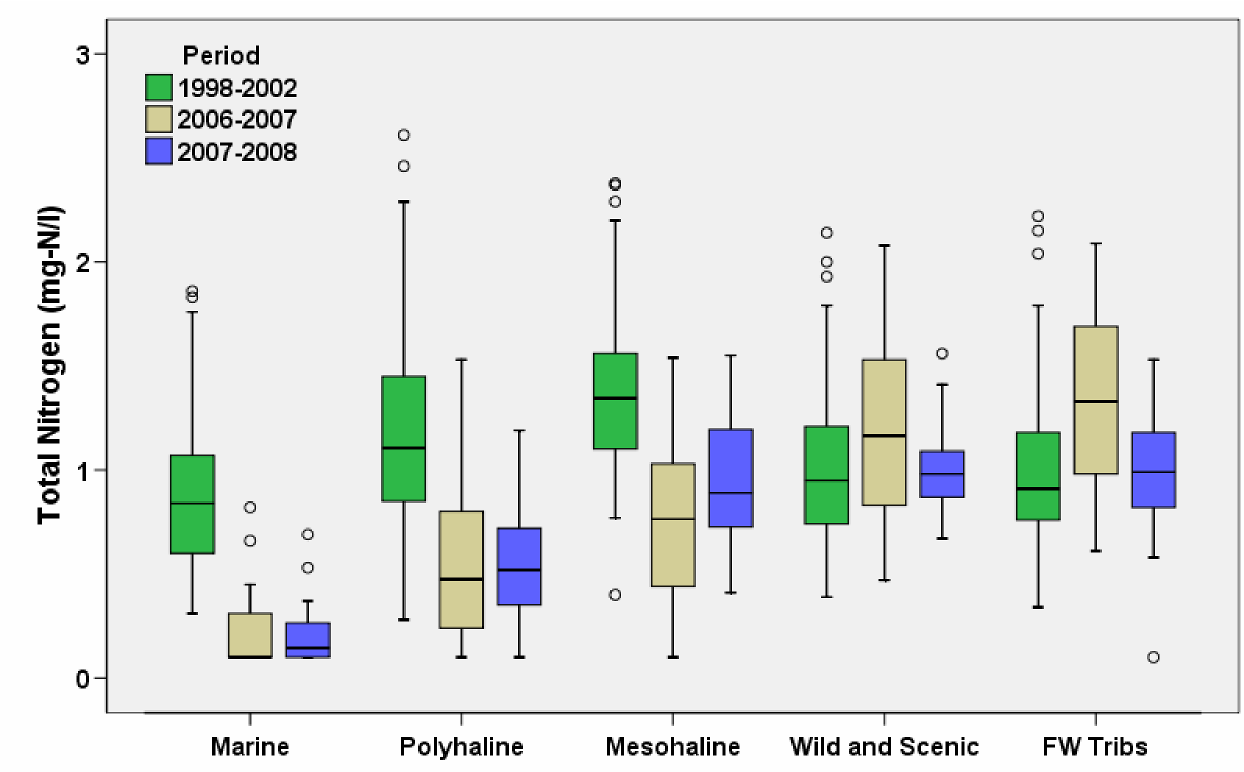

Period
1998-2002
2006-2007
2007-2008
Color (pcu)
0
50
100
150
200
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs

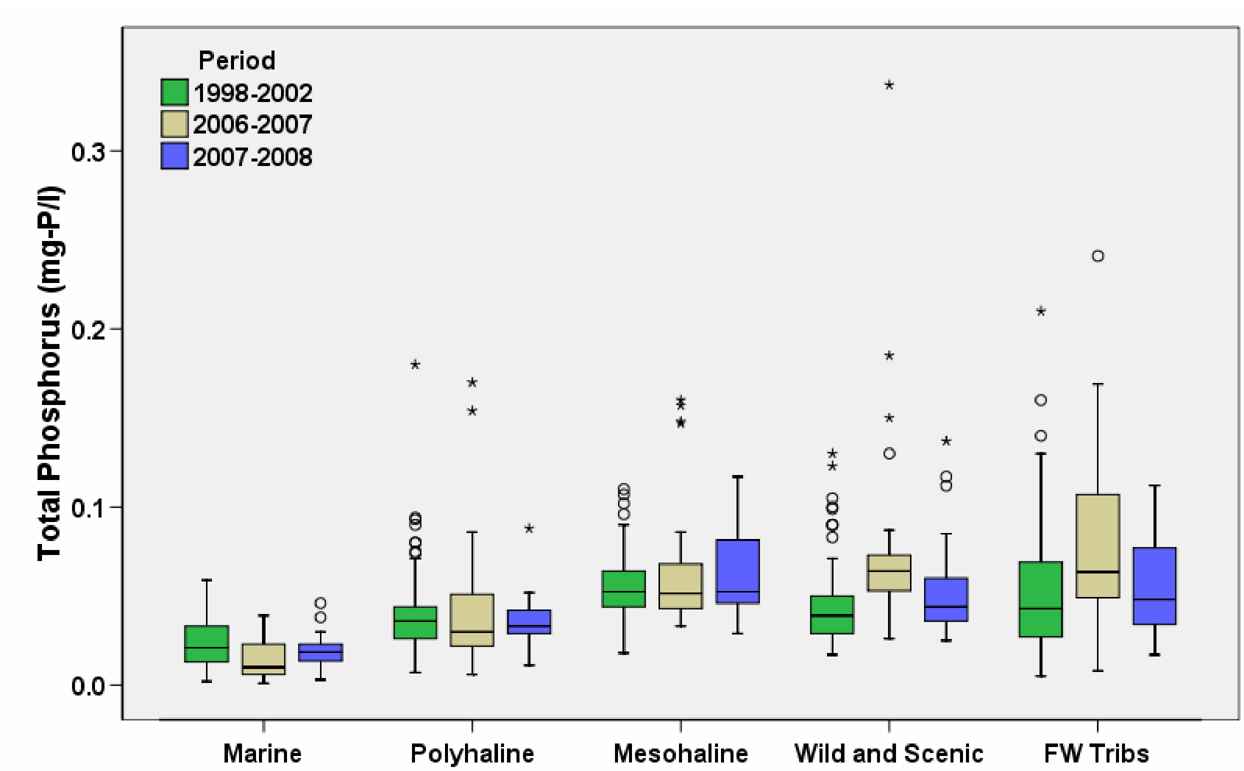

Dissolved Oxygen (mg/l)
10
8
6
4
2
0
Period
1998-2002
2006-2007
2007-2008
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs

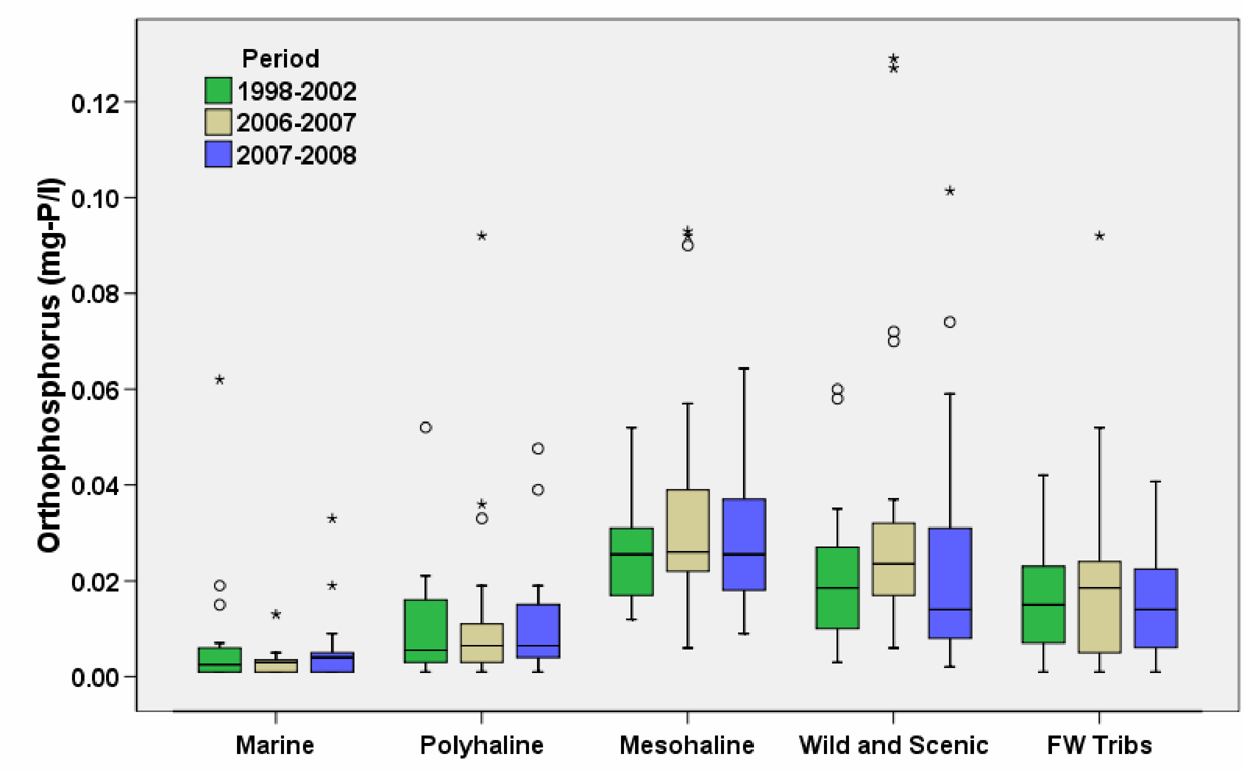

Fecal Coliform (cfu/100 ml)
10000
1000
100
10
1
0.001
Period
1998-2002
2006-2007
2007-2008
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs

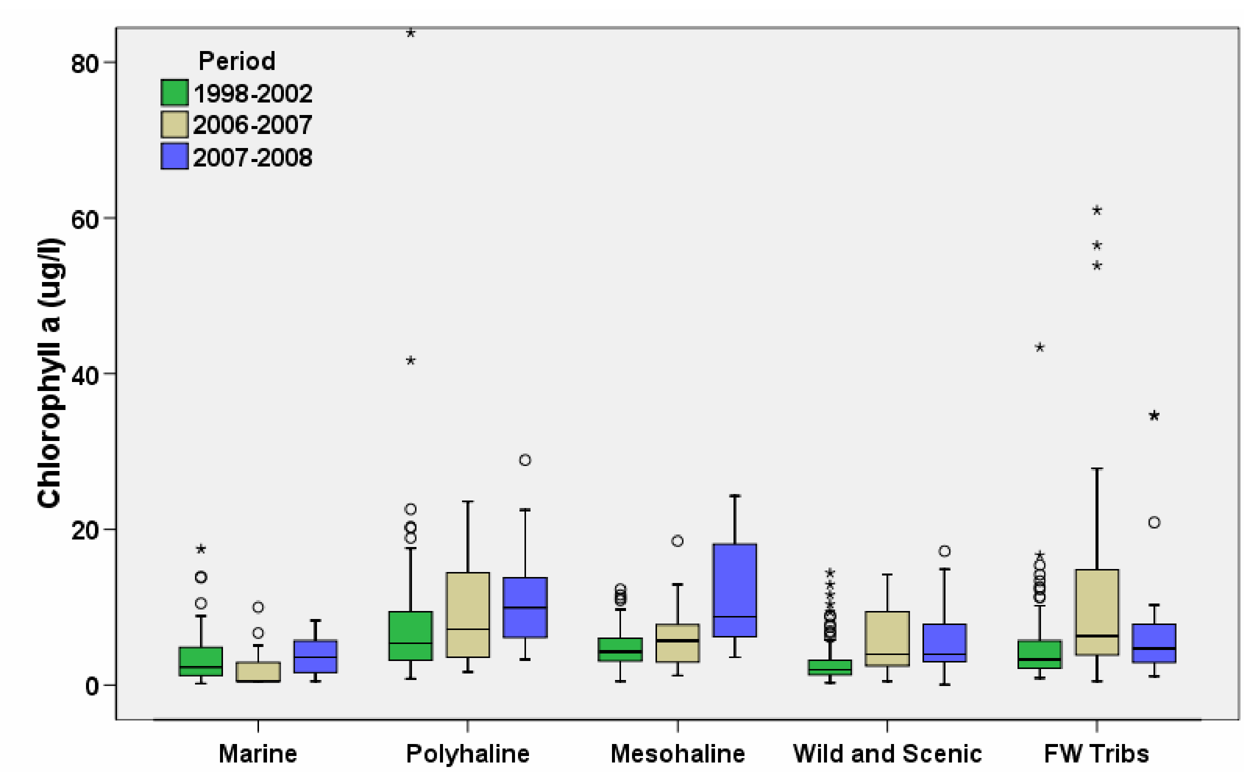

Period
1998-2002
2006-2007
2007-2008
Total Kjehldahl Nitrogen (mg-N/l)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs

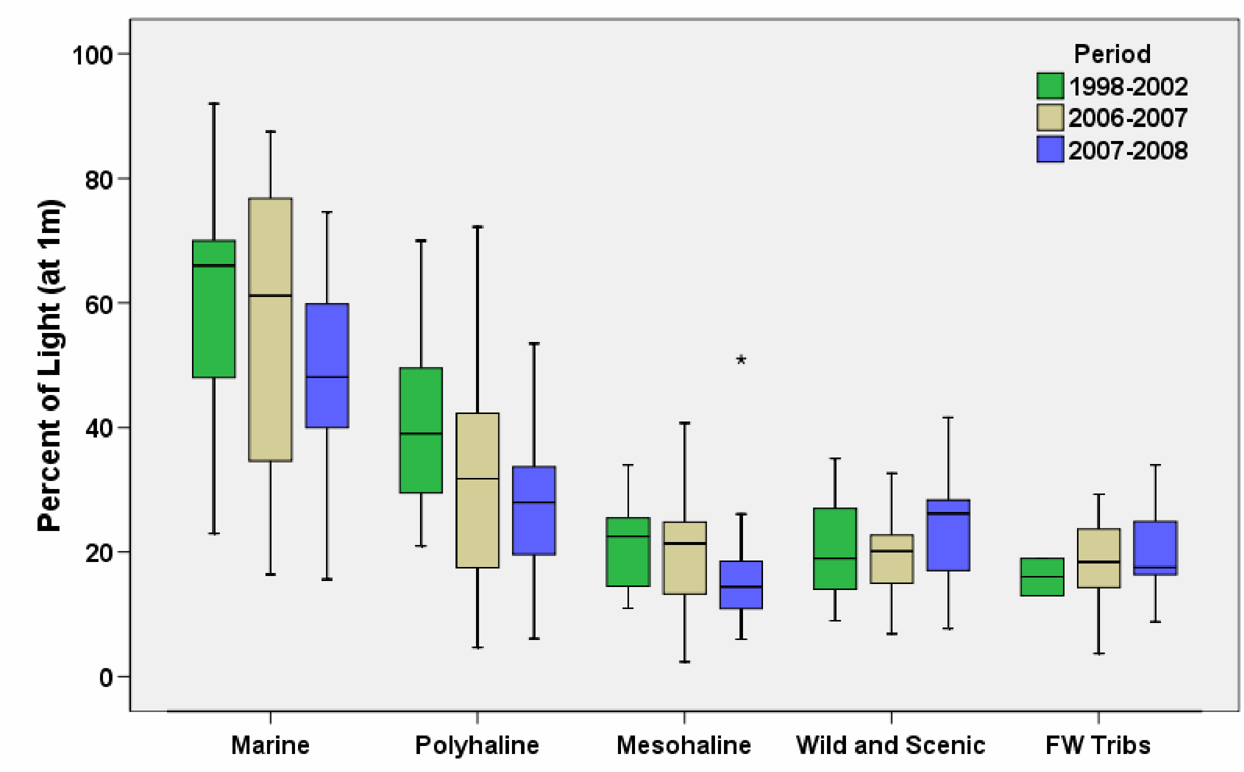

Period
1998-2002
2006-2007
2007-2008
Nitrate + Nitrite (mg-N/l)
0.3
0.2
0.1
0.0
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs


Period
1998-2002
2006-2007
2007-2008
Total Nitrogen (mg-N/l)
3
2
1
0
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs


Period
1998-2002
2006-2007
2007-2008
Total Phosphorus (mg-P/l)
0.3
0.2
0.1
0.0
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs


Period
1998-2002
2006-2007
2007-2008
Orthophosphorus (mg-P/l)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs


Period
1998-2002
2006-2007
2007-2008
Chlorophyll a (ug/l)
0
20
40
60
80
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs


Period
1998-2002
2006-2007
2007-2008
Percent of Light (at 1m)
100
80
60
40
20
0
Marine
Polyhaline
Mesohaline
Wild and Scenic
FW Tribs