2018 Martin Reservoir Report

Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Rivers and Reservoirs Unit
March 2022

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TABLE OF CONTENTS

LIST OF ACRONYMS

A&I	Agriculture and Industry water supply use classification
ADEM	Alabama Department of Environmental Management
AGPT	Algal Growth Potential Test
APCo	Alabama Power Company
CHL *a*	Chlorophyll *a*
DO	Dissolved Oxygen
F&W	Fish and Wildlife
MAX	Maximum
MDL	Method Detection Limit
MIN	Minimum
MSC	Mean Standing Crop
NTU	Nephelometric Turbidity Units
OAW	Outstanding Alabama Waters
ONRW	Outstanding National Resource Water
PWS	Public Water Supply
QAPP	Quality Assurance Project Plan
RRMP	Rivers and Reservoirs Monitoring Program
S	Swimming and Other Whole Body Water-Contact Sports
SD	Standard Deviation
SOP	Standard Operating Procedures
TEMP	Temperature
TN	Total Nitrogen
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSI	Trophic State Index
TSS	Total Suspended Solids
USACE	United States Army Corp of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Martin Reservoir, located near Alexander City, Alabama, is the second reservoir on the Tallapoosa River in Alabama, located downstream of Harris Reservoir. Created in the 1920s by the completion of Martin Dam, Martin Reservoir is approximately 31 miles long and covers over 40,000 acres.

The Alabama Department of Environmental Management (ADEM) monitored Martin Reservoir as part of the 2015 and 2018 assessments of the Tallapoosa River basin under the Rivers and Reservoirs Monitoring Program (RRMP). ADEM began monitoring lake water quality statewide in 1985, followed by a second statewide survey in 1989. In 1990, the Reservoir Water Quality Monitoring Program (now known as RRMP) was initiated by the Field Operations Division of the ADEM. The current objectives of this program are to provide data that can be used to assess current water quality conditions, to identify trends in water quality conditions, and to develop Total Maximum Daily Loads (TMDLs) and water quality criteria. Descriptions of all RRMP monitoring activities are available in ADEM's 2017 Monitoring Strategy (ADEM 2017).

Specific water quality criteria for nutrient management were implemented in 2002 at three locations on Martin Reservoir (Table 1). These criteria represent a growing season mean (April-October) chlorophyll *a* (chl *a*) concentrations that are protective of the reservoir's Public Water Supply, Swimming, and Fish & Wildlife (PWS/S/F&W) use classification, as well as Martin Reservoir's designation as a Treasured Alabama Lake (TAL). Impoundments or lakes with a high quality that constitute an exceptional resource of the State of Alabama can get this special designation. In 2011, certain segments of Martin Reservoir were designated a TAL, which limits new point sources by requiring them to meet a monthly average effluent limitation of 1.0 mg/L total phosphorus.

The purpose of this report is to summarize data collected at eleven stations in Martin Reservoir during the 2015 and 2018 growing seasons and to evaluate trends in mean lake trophic status and nutrient concentrations using ADEM's historic dataset. Monthly and mean concentrations of nutrients [total nitrogen (TN); total phosphorus (TP)], algal biomass/productivity [chl *a*; algal growth potential testing (AGPT)], sediment [total suspended solids (TSS)], and trophic state [Carlson's trophic state index (TSI)] were compared to ADEM's existing data and established criteria.

METHODS

Sampling stations were selected using historical data and previous assessments (Figure 1). Specific location information can be found in Table 1. The mainstem of Martin Reservoir was sampled in the dam forebay, mid reservoir, and two locations in the upper reservoir (upper and upstream 280). Six tributary embayment stations were sampled in the upper (Hillabee and Coley Creek) and mid (Elkahatchee, Manoy, Sandy, and Blue Creek) reservoir. Kowaliga Creek constitutes a very large portion of the lower reservoir and is treated as a mainstem station in this report.

Water quality sampling was conducted at monthly intervals through the growing season, April-October. All samples were collected, preserved, stored, and transported according to procedures in the ADEM Field Operations Division Standard Operating Procedures (ADEM 2018a), Surface Water Quality Assurance Project Plan (ADEM 2018b), and Quality Management Plan (ADEM 2018c).

Mean growing season TN, TP, chl *a*, and TSS were calculated to evaluate water quality conditions at each site. For mainstem stations, monthly concentrations of these parameters were graphed with the closest available Alabama Power Company discharge data and ADEM's previously collected data to help interpret the results.

Figure 1. Martin Reservoir with sampling locations. A description of each sampling location is provided in Table 1.

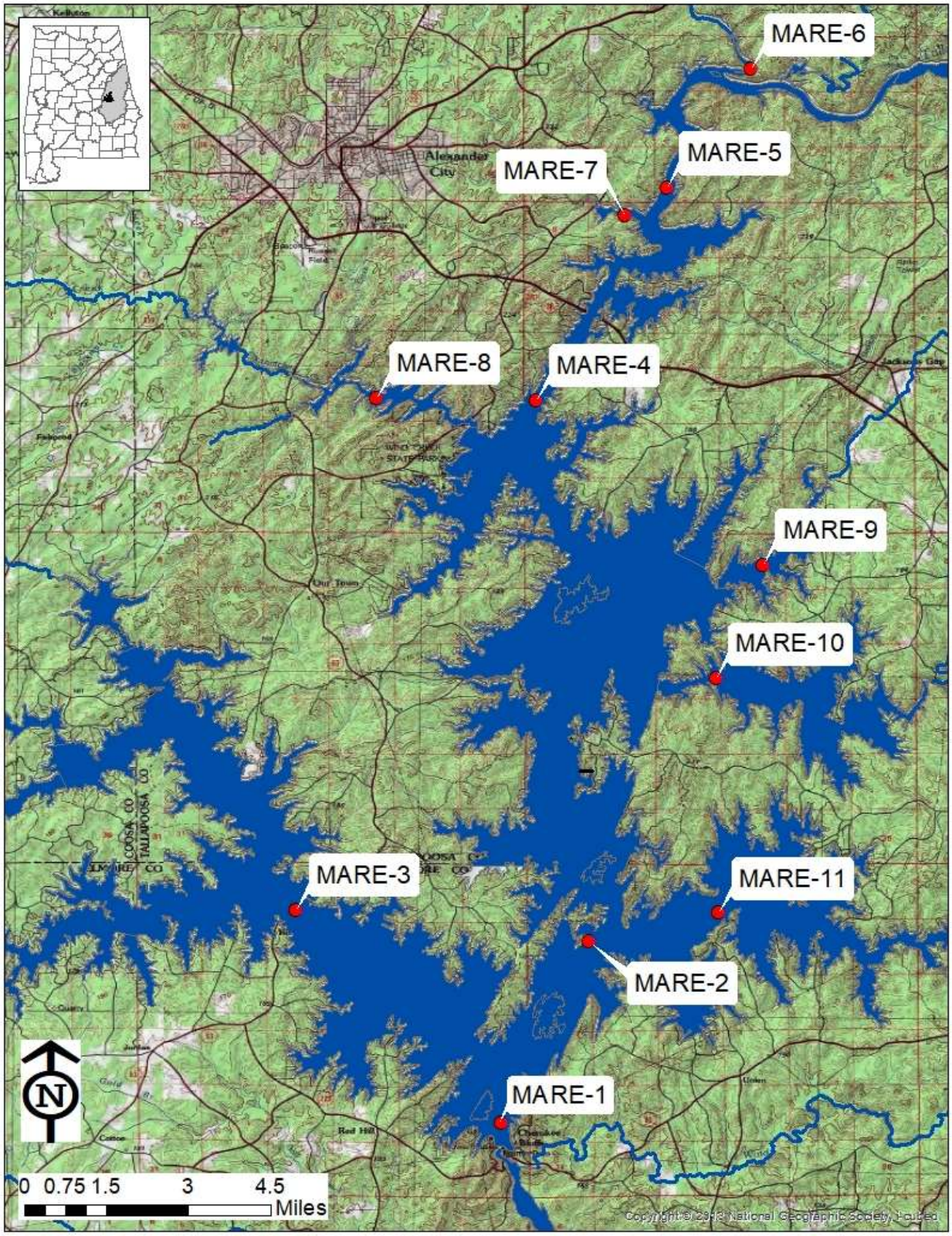


Table 1. Location information, station description, county, waterbody, chl *a* criteria, and latitude and longitude for monitoring stations in Martin Reservoir.

Martin Reservoir								
HUC	**County**	**Station Number**	**Report Designation**	**Waterbody Name**	**Station Description**	**Chl *a* Criteria**	**Latitude**	**Longitude**
Middle Tallapoosa (0315-0109)								
031501090805	Elmore	MARE-1*	Lower	Tallapoosa R	Deepest point, main river channel, dam forebay.	5 μg/L	32.6865	-85.9107
031501090805	Elmore	MARE-2*	Mid	Tallapoosa R	Deepest point, main river channel, immediately. upstream of Blue Creek embayment.	5 μg/L	32.7344	-85.8874
031501090703	Elmore	MARE-3*	Kowaliga	Kowaliga Ck	Deepest point, main creek channel, immediately upstream of Alabama Hwy 63 bridge.	5 μg/L	32.7428	-85.9649
031501090804	Tallapoosa	MARE-4	Upper	Tallapoosa R	Deepest point, main river channel, upstream of Wind Creek State Park.		32.8775	-85.9013
031501090802	Tallapoosa	MARE-5	Upstream 280	Tallapoosa R	Deepest point, main river channel, approximately 0.5 miles upstream of Coley Creek embayment.		32.9336	-85.8669
031501090406	Tallapoosa	MARE-6	Hillabee Ck	Hillabee Ck	Deepest point, main creek channel, Hillabee Creek embayment, approximately 0.5 miles upstream of lake confluence.		32.9650	-85.8444
031501090802	Tallapoosa	MARE-7	Coley Ck	Coley Ck	Deepest point, main creek channel, Coley Creek embayment, approx. 0.5 miles upstream of lake confluence.		32.9264	-85.8778
031501090803	Tallapoosa	MARE-8	Elkahatchee Ck	Elkahatchee Ck	Deepest point, main creek channel, Elkahatchee Creek embayment, approximately 0.5 miles downstream of Elkahatchee/Sugar Creek confluence.		32.8781	-85.9436
031501090804	Tallapoosa	MARE-9	Manoy Ck	Manoy Ck	Deepest point, main creek channel, Manoy Creek embayment, approximately 1.0 mile upstream of lake confluence.		32.8339	-85.8414
031501090504	Tallapoosa	MARE-10	Sandy Ck	Sandy Ck	Deepest point, main creek channel, Sandy Creek embayment, approximately 1.0 mile upstream of lake confluence.		32.8039	-85.8539
031501090602	Tallapoosa	MARE-11	Blue Ck	Blue Ck	Deepest point, main creek channel, Blue Creek embayment, approximately 2.0 miles upstream of lake confluence.		32.7419	-85.8531

*Growing season mean chl. *a* criteria implemented at the station in 2002

RESULTS

Growing season mean graphs for TN, TP, chl *a*, and TSS are provided in this section (Figures 2-5). Monthly graphs for TN, TP, chl *a*, TSS, DO, and TSI are also provided (Figures 6-15 & 20-21), with mean monthly discharge included as an indicator of flow and retention time in the months sampled. AGPT results appear in Table 2. Depth profile graphs of temperature, conductivity, and DO appear in Figsures 16-19. Summary statistics of all data collected during 2015 and 2018 are presented in Appendix Table 1 and Appendix Table 2. The tables contain the minimum, maximum, median, mean, and standard deviation of each parameter analyzed.

Stations with the highest concentrations of nutrients, chlorophyll *a*, and TSS are noted in the paragraphs to follow. Though stations with lowest concentrations may not be mentioned, review of the graphs that follow will indicate these stations that may be potential candidates for reference waterbodies and watersheds.

In 2015 and 2018, the highest mean growing season TN value among mainstem stations was in the upper station, while the highest value among tributary stations was in Coley Creek (Figure 2). Mean TN values appeared to decline in all mainstem stations 2013-2018. With the exception of Manoy Creek, mean TN in all tributaries reached their highest concentrations on record in 2015 and then declined in 2018. Historic high monthly TN concentrations were measured in 2015 at the upstream 280 station in September and at the Kowliga station in July (Figures 6 & 7). In 2018, most monthly concentrations were near or below historic means.

In 2015 and 2018, the highest mean growing season TP value among mainstem stations was in the upstream 280 station, while the highest value among tributary stations was in Coley Creek (Figure 3). Growing season mean TP values at all stations have appeared to decline since 2005/2006 and seem to have stabilized. Monthly TP concentrations at all stations were at or below historic means April-October in both sampling years (Figures 8 & 9).

Specific water quality criteria for nutrient management were established for the mid, Kowaliga, and lower stations in Martin Reservoir in 2002. The growing season mean chl *a* value for the Kowliga station exceeded the compliance criteria limit during 2018. In 2015, the highest mean growing season chl *a* value among mainstem stations was in the upper station, while the highest mainstem value in 2018 was in the Kowliga station (Figure 4). Among tributary stations,

the highest mean was in Coley Creek during both 2015 and 2018. Mean concentrations increased in all stations monitored between 2015 and 2018. During 2015, historic high monthly chl *a* concentrations were measured in the upper and mid stations in August. During 2018, historic high concentrations were measured in the upper station during April and June, in Kowliga and the lower station during April, July, and August, and in the mid station in June (Figures 10 & 11).

In 2015, the highest mean growing season TSS value among mainstem stations was in the mid station. This value was elevated due to an extremely high concentration measured in May (Figure 5). The highest mainstem value in 2018 was in the upstream 280 station. Among tributary stations, the highest mean was in Hillabee Creek during both 2015 and 2018. With the exception of the mid station in 2015, growing season mean TSS concentrations at all mainstem stations appear to have declined since 2004. Other than the May 2015 value measured at the mid station, monthly TSS concentrations in the mainstem stations were similar to or below mean historic values in both years of sampling (Figues 12 & 13).

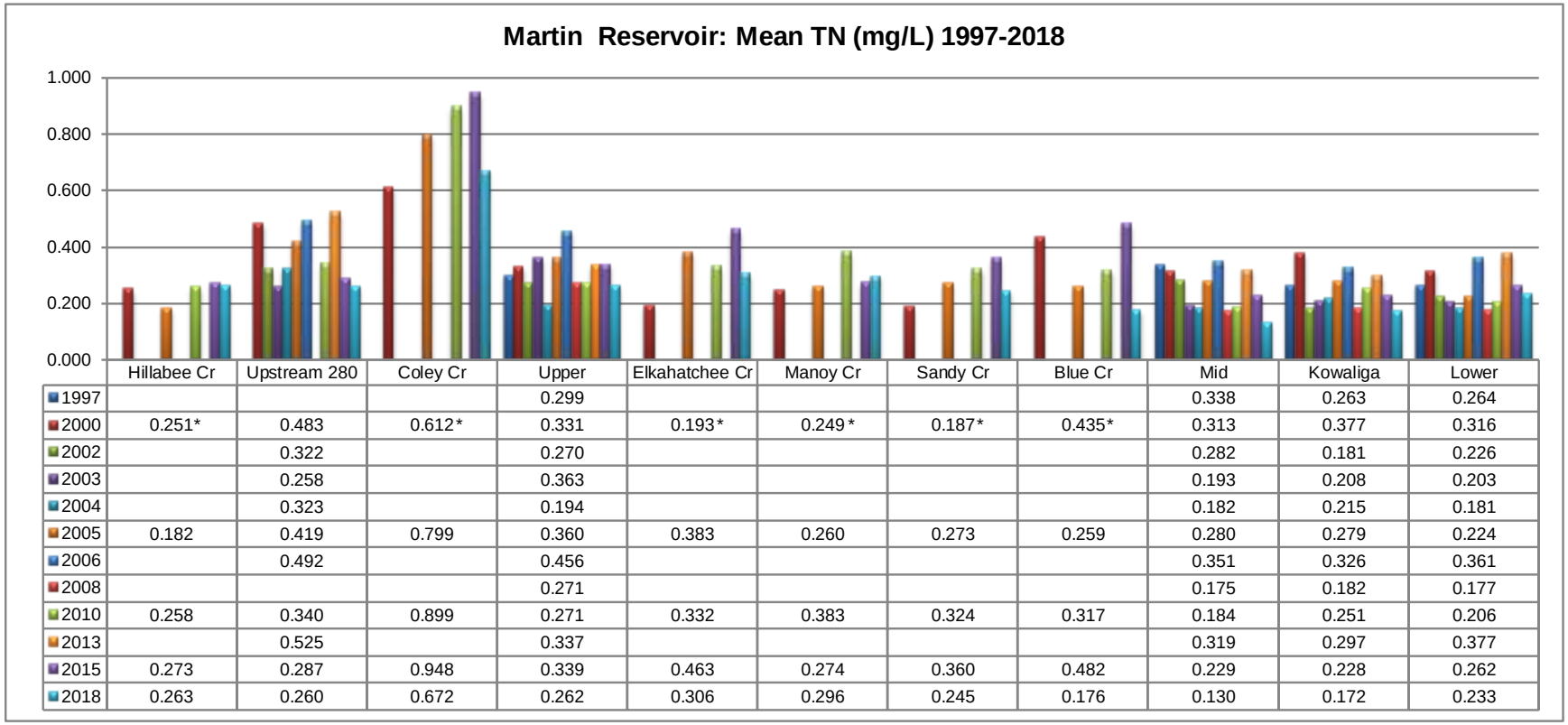
Of the eleven stations monitored in 2015, AGPT results indicated three Martin locations that were not phosphorus limited; Hillabee and Elkahatchee Creeks were co-limited, and Coley Creek was nitrogen limited (Table 2). Raschke and Schultz (1987) defined a mean standing crop (MSC) value of 5.0 mg/L as protective of reservoir and lake systems. All locations sampled in 2015 were below 5.0 mg/L, except Coley Creek. The MSC concentration in Coley Creek was near 25 mg/L. No AGPT samples were collected at Martin Reservoir in 2018.

All measurements of dissolved oxygen concentrations in Martin Reservoir during 2015 and 2018 met the ADEM criteria limit of 5.0 mg/L at 5.0 ft (1.5 m) (ADEM Admin. Code R. 335-6-10-.09) (Figures 14 & 15). During 2015, the upper reservoir station was thermally and chemically stratified May-September, while the lower station was stratified April-October (Figures 16 & 17). During 2015, the water column in the lower station had a zone of deoxygenation beginning between 10-17 meters from June-October, while in the upper station the zone began between 6-11 meters and lasted from May-September. During 2018, the lower reservoir station was thermally and chemically stratified April-October (Figures 18 & 19). The upper station was chemically stratified May-September and showed only weak thermal stratification. The water column at the lower station had a zone of deoxygenation beginning between 8-20 meters from May-October,

while the in the upper station the zone began between 7-10 meters and lasted from May-September. Highest temperatures were reached during July.

TSI values were calculated using monthly chl *a* concentrations and Carlson's Trophic State Index (1977). During 2015, the upper station was eutrophic in July, August, and September, the Kowliga station was eutrophic in July and August, and the mid station was eutrophic in August (Figure 20). Eutrophic or near eutrophic conditions were measured in Coley Creek from July-October, in Elkahatchee Creek in July, September, and October, in and Hillabee, Manoy, and Blue Creeks in July. During 2018, eutrophic or near eutrophic conditions were measured in the upstream 280 station in June, July, and September, in the upper station in June, July, and August, in the mid station in June, and in the Kowliga and lower stations during July and August (Figure 21). Eutrophic or near eutrophic conditions were also measured in Elkahatchee Creek in April, June-July, and September-October, in Hillabee and Coley Creeks during June-July and September-October, in Manoy Creek in May, June, and July, in Sandy Creek in June and August, and in Blue Creek in June and July.

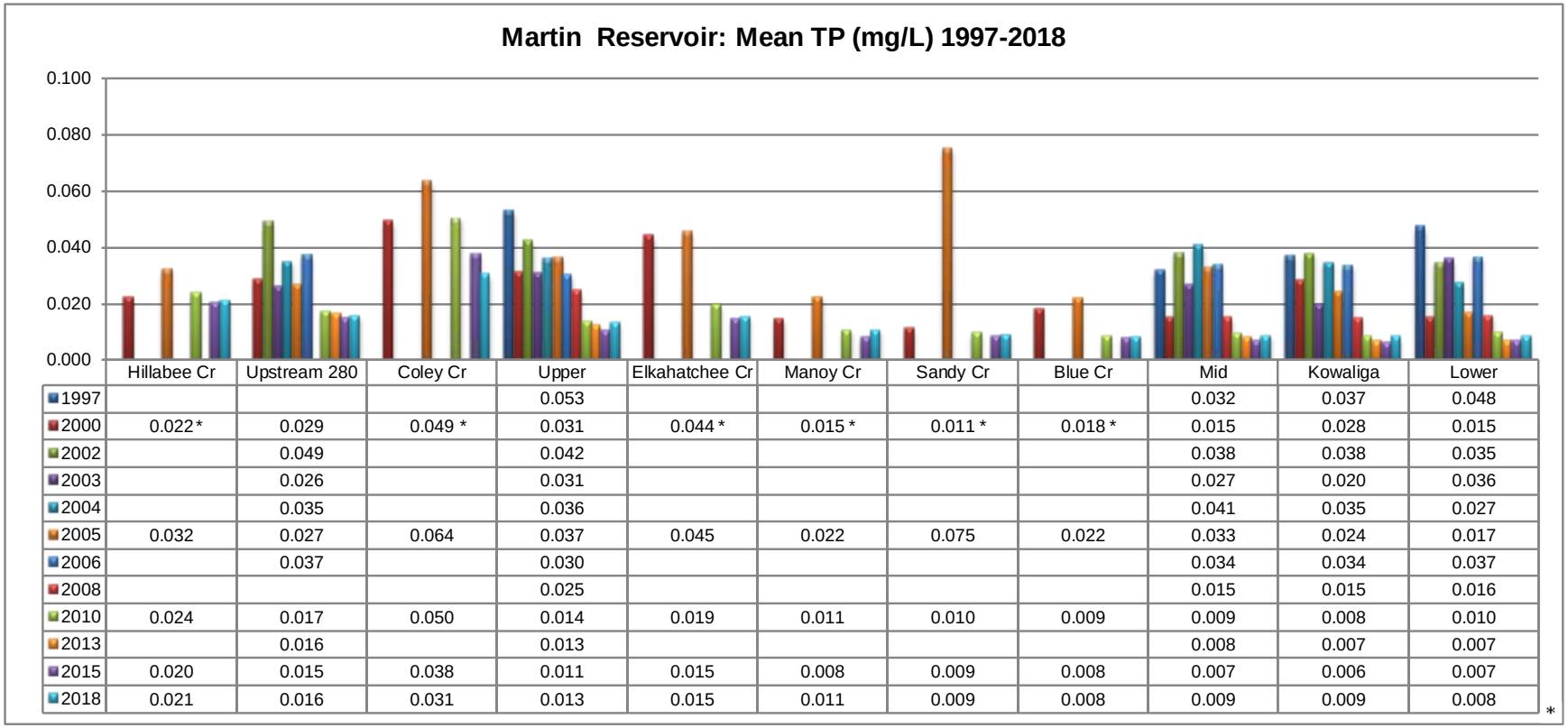
Figure 2. Mean growing season TN measured in Martin Reservoir, April-October 1997-2018. Stations are illustrated from upstream to downstream as the graph is read from left to right.



	Hillabee Cr	Upstream 280	Coley Cr	Upper	Elkahatchee Cr	Manoy Cr	Sandy Cr	Blue Cr	Mid	Kowaliga	Lower
1997				0.299					0.338	0.263	0.264
2000	0.251*	0.483	0.612*	0.331	0.193*	0.249*	0.187*	0.435*	0.313	0.377	0.316
2002		0.322		0.270					0.282	0.181	0.226
2003		0.258		0.363					0.193	0.208	0.203
2004		0.323		0.194					0.182	0.215	0.181
2005	0.182	0.419	0.799	0.360	0.383	0.260	0.273	0.259	0.280	0.279	0.224
2006		0.492		0.456					0.351	0.326	0.361
2008				0.271					0.175	0.182	0.177
2010	0.258	0.340	0.899	0.271	0.332	0.383	0.324	0.317	0.184	0.251	0.206
2013		0.525		0.337					0.319	0.297	0.377
2015	0.273	0.287	0.948	0.339	0.463	0.274	0.360	0.482	0.229	0.228	0.262
2018	0.263	0.260	0.672	0.262	0.306	0.296	0.245	0.176	0.130	0.172	0.233

*Mean of April, June, August.

Figure 3. Mean growing season TP measured in Martin Reservoir, April-October 1997-2018. Stations are illustrated from upstream to downstream as the graph is read from left to right.

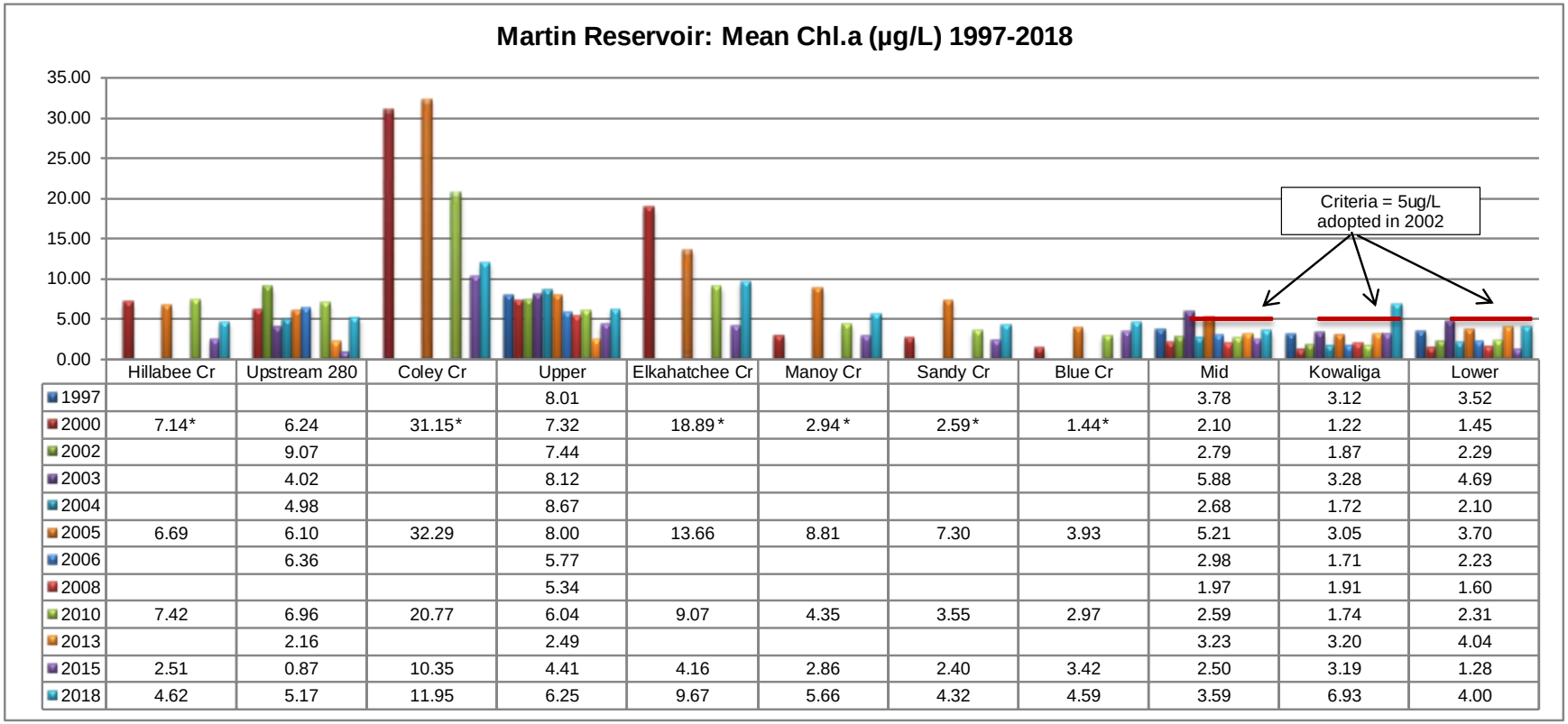


	Hillabee Cr	Upstream 280	Coley Cr	Upper	Elkahatchee Cr	Manoy Cr	Sandy Cr	Blue Cr	Mid	Kowaliga	Lower
1997				0.053					0.032	0.037	0.048
2000	0.022 *	0.029	0.049 *	0.031	0.044 *	0.015 *	0.011 *	0.018 *	0.015	0.028	0.015
2002		0.049		0.042					0.038	0.038	0.035
2003		0.026		0.031					0.027	0.020	0.036
2004		0.035		0.036					0.041	0.035	0.027
2005	0.032	0.027	0.064	0.037	0.045	0.022	0.075	0.022	0.033	0.024	0.017
2006		0.037		0.030					0.034	0.034	0.037
2008				0.025					0.015	0.015	0.016
2010	0.024	0.017	0.050	0.014	0.019	0.011	0.010	0.009	0.009	0.008	0.010
2013		0.016		0.013					0.008	0.007	0.007
2015	0.020	0.015	0.038	0.011	0.015	0.008	0.009	0.008	0.007	0.006	0.007
2018	0.021	0.016	0.031	0.013	0.015	0.011	0.009	0.008	0.009	0.009	0.008

*

*Mean of April, June, August.

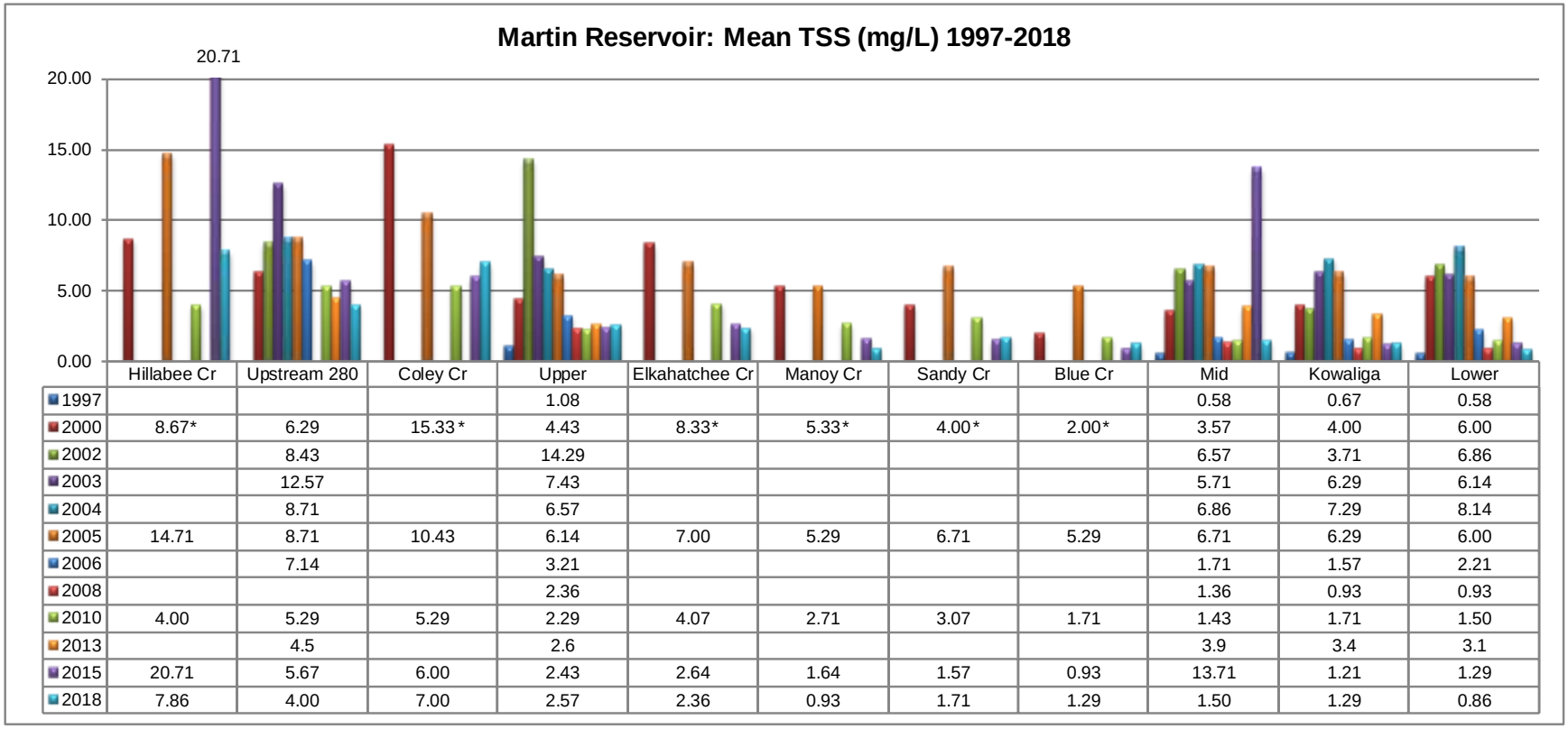
Figure 4. Mean growing season chl *a* measured in Martin Reservoir April-October, 1997-2018. Stations are illustrated from upstream to downstream as the graph is read from left to right.



	Hillabee Cr	Upstream 280	Coley Cr	Upper	Elkahatchee Cr	Manoy Cr	Sandy Cr	Blue Cr	Mid	Kowaliga	Lower
1997				8.01					3.78	3.12	3.52
2000	7.14*	6.24	31.15*	7.32	18.89*	2.94*	2.59*	1.44*	2.10	1.22	1.45
2002		9.07		7.44					2.79	1.87	2.29
2003		4.02		8.12					5.88	3.28	4.69
2004		4.98		8.67					2.68	1.72	2.10
2005	6.69	6.10	32.29	8.00	13.66	8.81	7.30	3.93	5.21	3.05	3.70
2006		6.36		5.77					2.98	1.71	2.23
2008				5.34					1.97	1.91	1.60
2010	7.42	6.96	20.77	6.04	9.07	4.35	3.55	2.97	2.59	1.74	2.31
2013		2.16		2.49					3.23	3.20	4.04
2015	2.51	0.87	10.35	4.41	4.16	2.86	2.40	3.42	2.50	3.19	1.28
2018	4.62	5.17	11.95	6.25	9.67	5.66	4.32	4.59	3.59	6.93	4.00

*Mean of April, June, August.

Figure 5. Mean growing season TSS measured in Martin Reservoir, April-October 1997-2018. Stations are illustrated from upstream to downstream as the graph is read from left to right.



	Hillabee Cr	Upstream 280	Coley Cr	Upper	Elkahatchee Cr	Manoy Cr	Sandy Cr	Blue Cr	Mid	Kowaliga	Lower
1997				1.08					0.58	0.67	0.58
2000	8.67*	6.29	15.33*	4.43	8.33*	5.33*	4.00*	2.00*	3.57	4.00	6.00
2002		8.43		14.29					6.57	3.71	6.86
2003		12.57		7.43					5.71	6.29	6.14
2004		8.71		6.57					6.86	7.29	8.14
2005	14.71	8.71	10.43	6.14	7.00	5.29	6.71	5.29	6.71	6.29	6.00
2006		7.14		3.21					1.71	1.57	2.21
2008				2.36					1.36	0.93	0.93
2010	4.00	5.29	5.29	2.29	4.07	2.71	3.07	1.71	1.43	1.71	1.50
2013		4.5		2.6					3.9	3.4	3.1
2015	20.71	5.67	6.00	2.43	2.64	1.64	1.57	0.93	13.71	1.21	1.29
2018	7.86	4.00	7.00	2.57	2.36	0.93	1.71	1.29	1.50	1.29	0.86

*Mean of April, June, August.

Figure 6. Monthly TN concentrations measured at upstream 280, upper, and Kowaliga stations in Martin Reservoir, April-October 2015 and 2018 vs. average monthly discharge. Monthly discharge acquired from Alabama Power at Martin Reservoir Dam. Each bar graph depicts monthly changes in each station. The historic mean (1992-2018) and min/max ranges are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

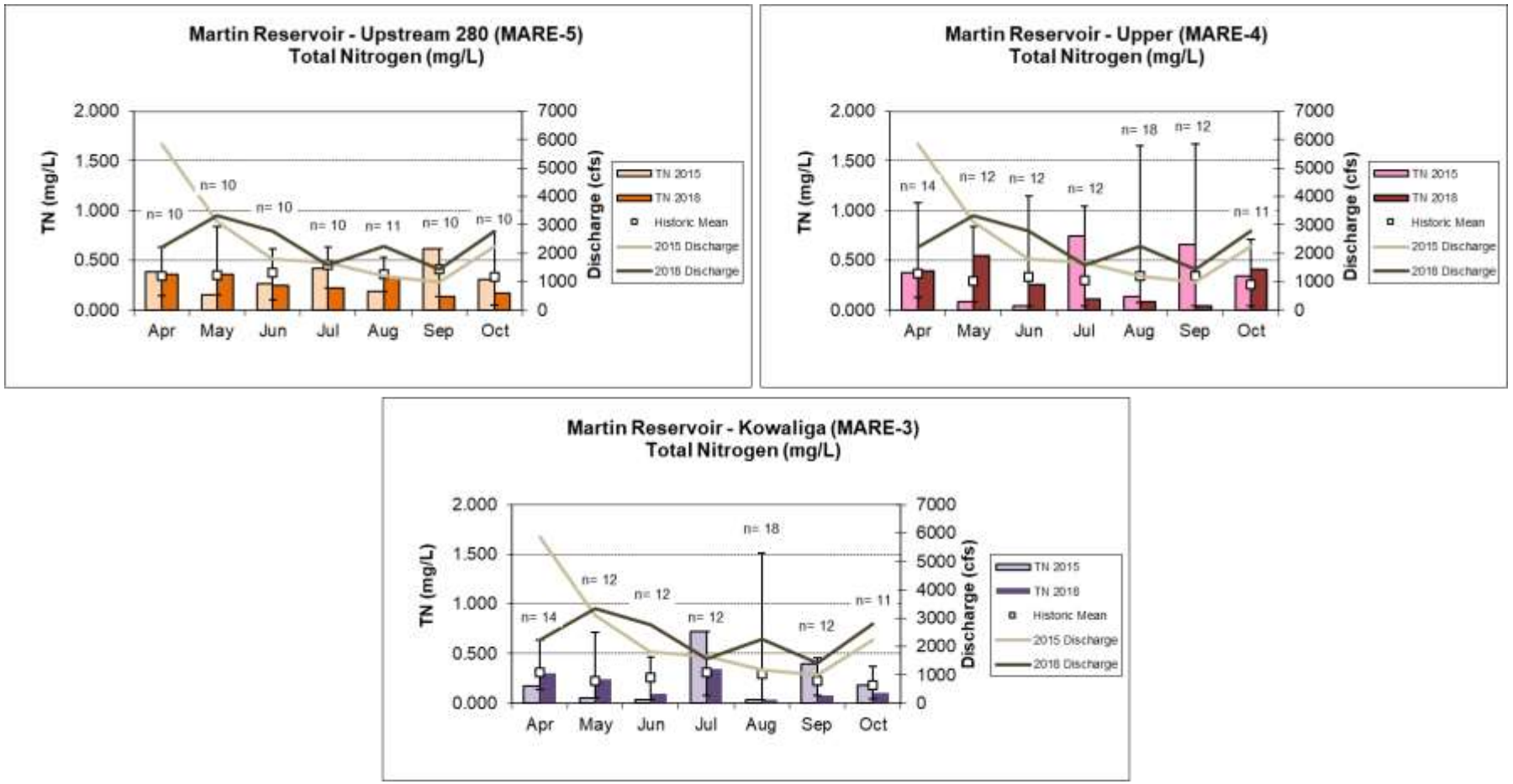


Figure 7. Monthly TN concentrations measured at mid and lower stations in Martin Reservoir, April-October 2015 and 2018 vs. average monthly discharge. Monthly discharge acquired from Alabama Power at Martin Reservoir Dam. Each bar graph depicts monthly changes in each station. The historic mean (1992-2018) and min/max ranges are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

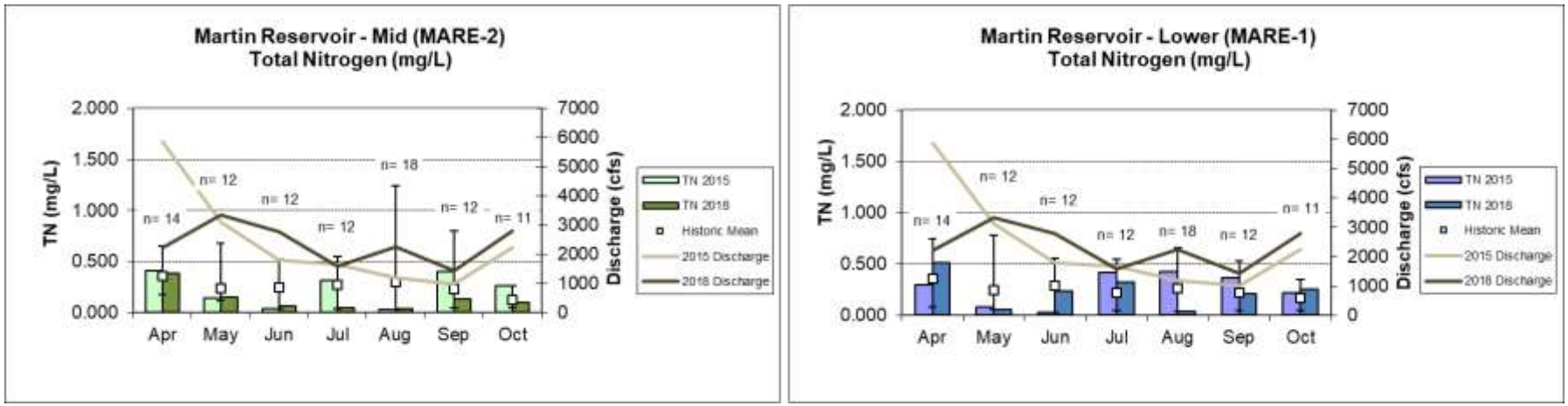


Figure 8. Monthly TP concentrations measured at upstream 280, upper, and Kowaliga stations in Martin Reservoir, April-October 2015 and 2018 vs. average monthly discharge. Monthly discharge acquired from Alabama Power at Martin Reservoir Dam. Each bar graph depicts monthly changes in each station. The historic mean (1992-2018) and min/max ranges are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

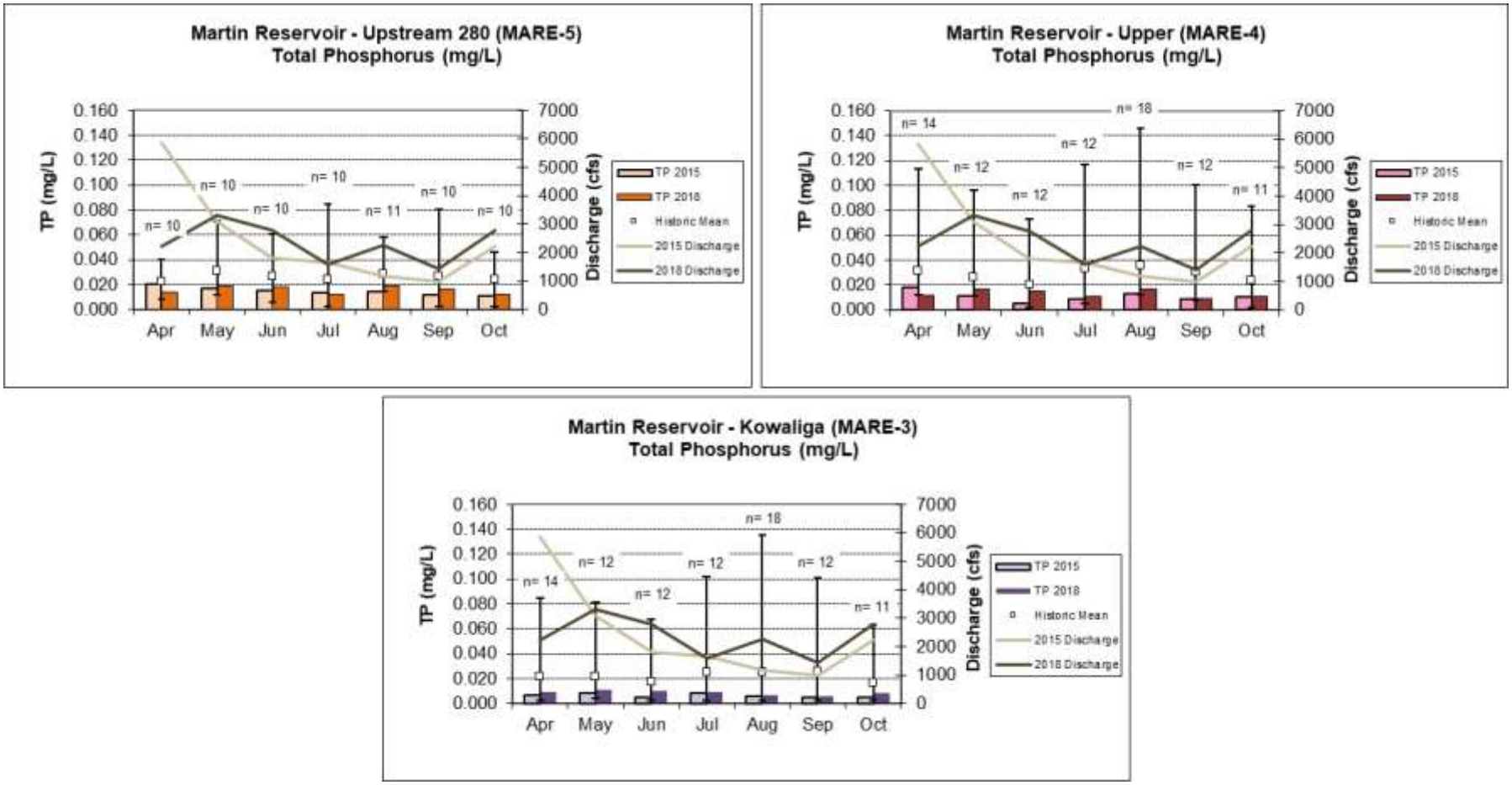
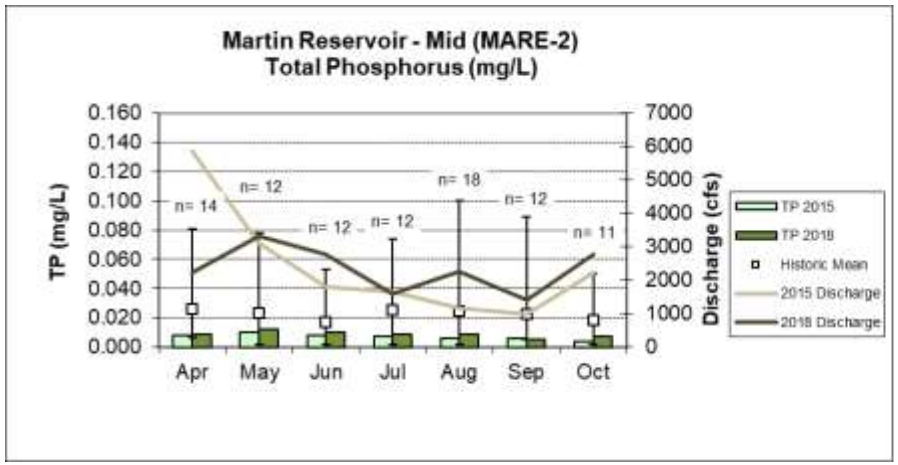


Figure 9. Monthly TP concentrations measured at mid and lower staions in Martin Reservoir, April-October 2015 and 2018 vs. average monthly discharge. Monthly discharge acquired from Alabama Power at Martin Reservoir Dam. Each bar graph depicts monthly changes in each station. The historic mean (1992-2018) and min/max ranges are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.



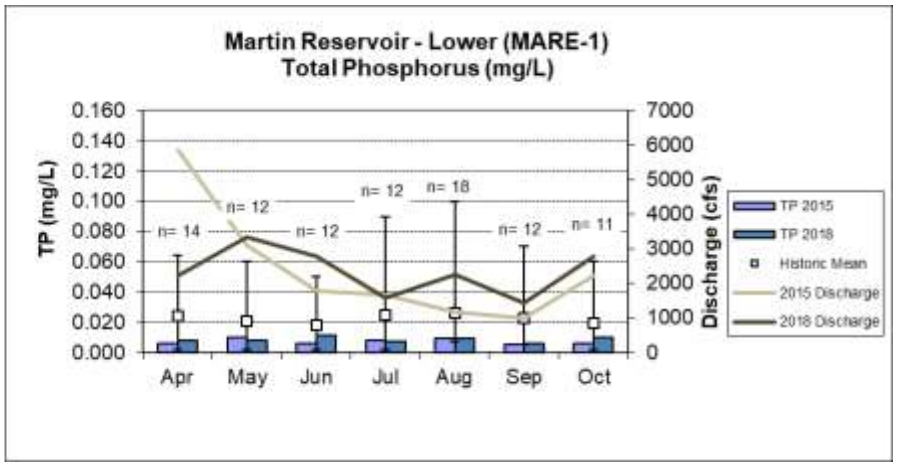


Figure 10. Monthly chlorophyll *a* concentrations measured at upstream 280, upper, and Kowaliga stations in Martin Reservoir, April-October 2015 and 2018 vs. average monthly discharge. Monthly discharge acquired from Alabama Power at Martin Reservoir Dam. Each bar graph depicts monthly changes in each station. The historic mean (1992-2018) and min/max ranges are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

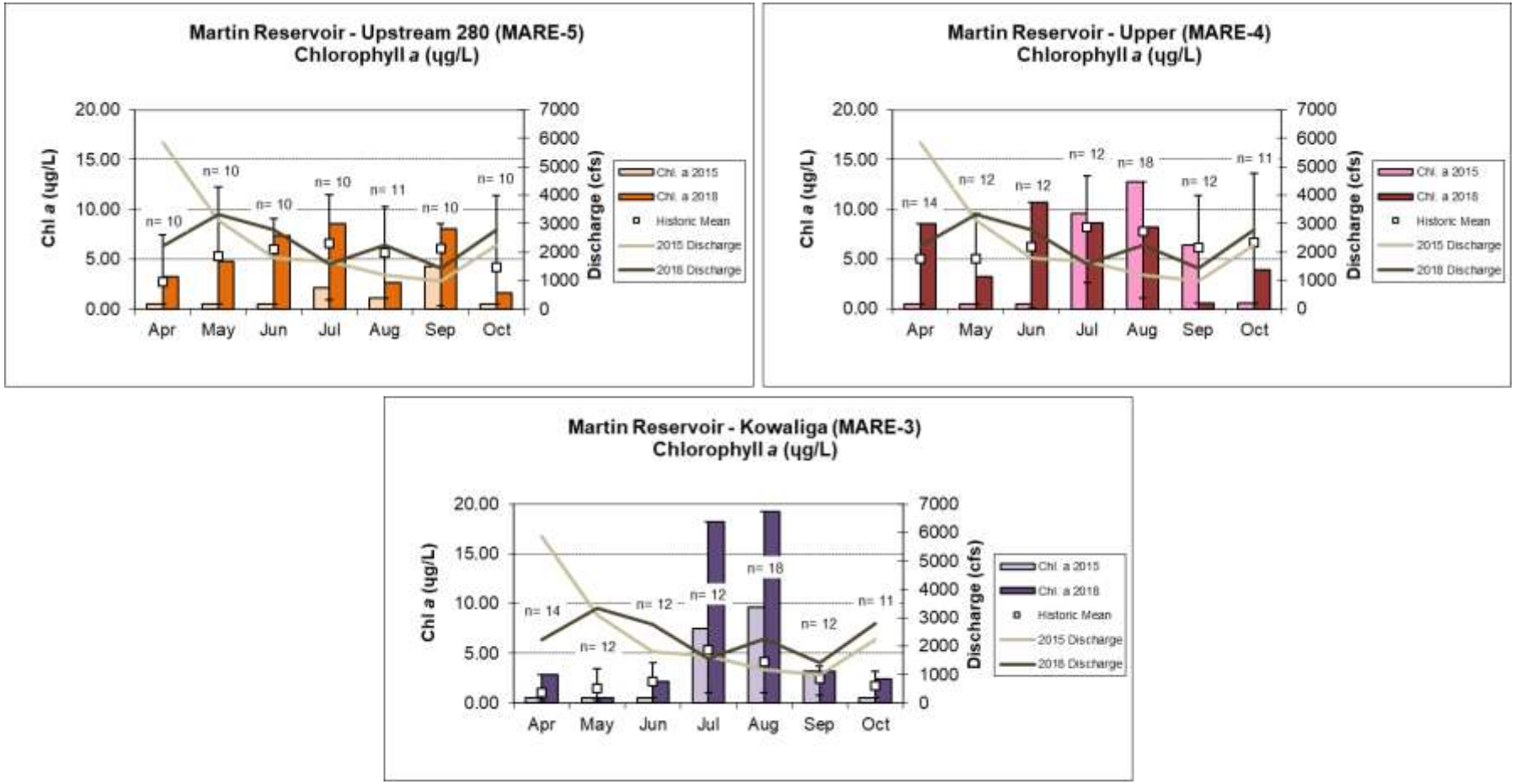
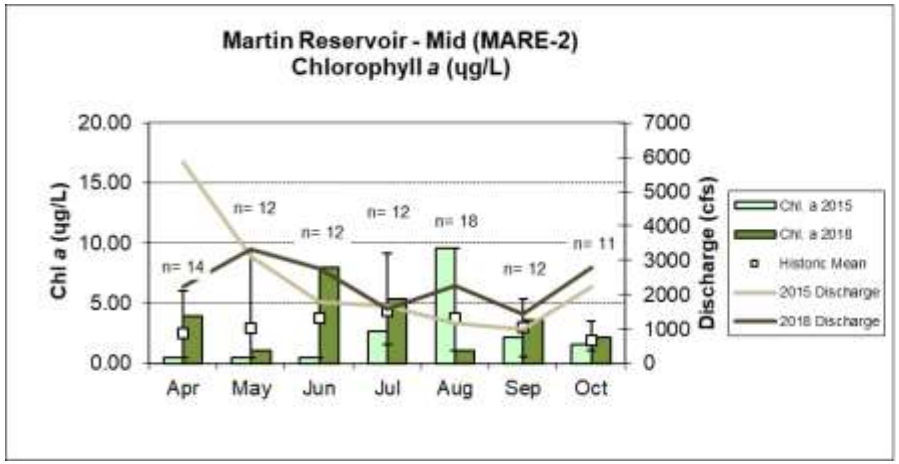


Figure 11. Monthly chlorophyll *a* concentrations measured at mid and lower stations in Martin Reservoir, April-October 2015 and 2018 vs. average monthly discharge. Monthly discharge acquired from Alabama Power at Martin Reservoir Dam. Each bar graph depicts monthly changes in each station. The historic mean (1992-2018) and min/max ranges are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.



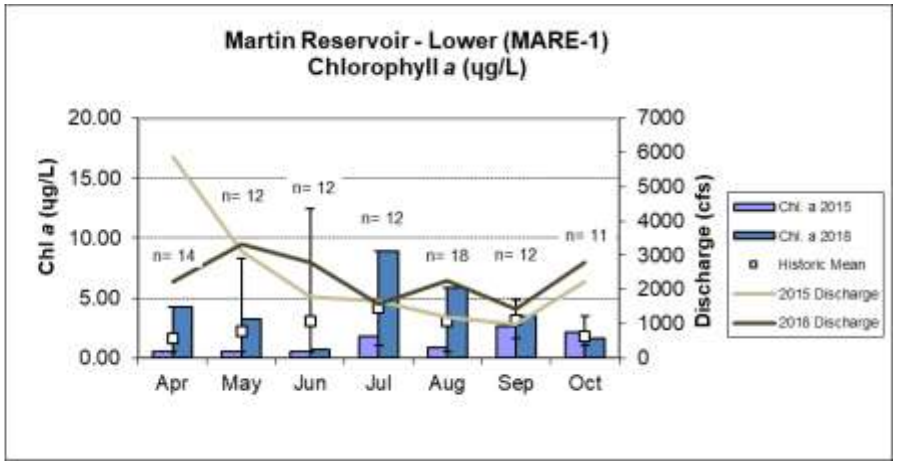
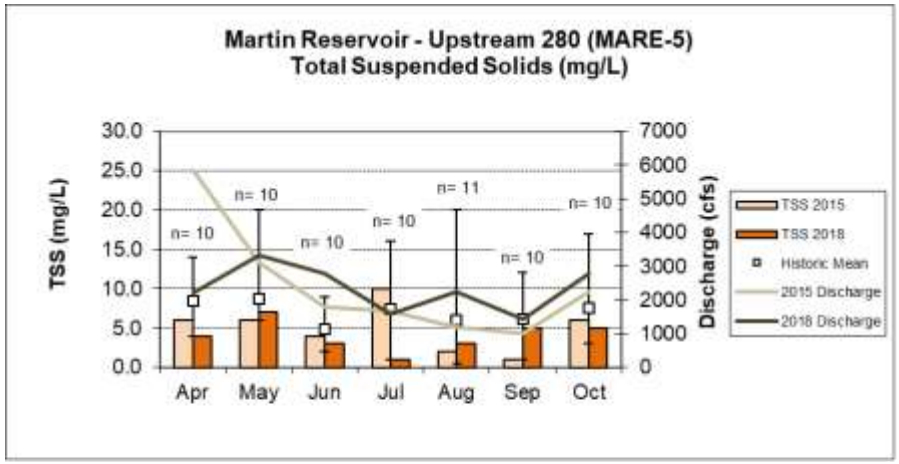
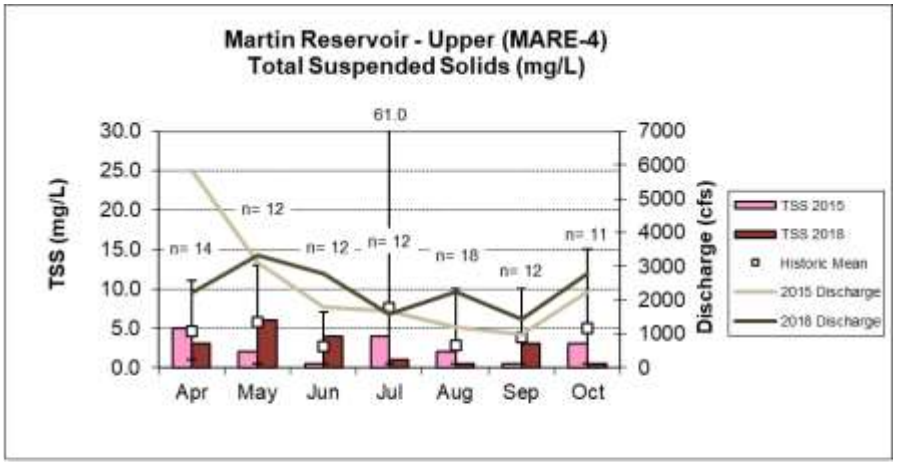


Figure 12. Monthly TSS concentrations measured at upstream 280, upper, and Kowaliga stations in Martin Reservoir, April-October 2015 and 2018 vs. average monthly discharge. Monthly discharge acquired from Alabama Power at Martin Reservoir Dam. Each bar graph depicts monthly changes in each station. The historic mean (1992-2018) and min/max ranges are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





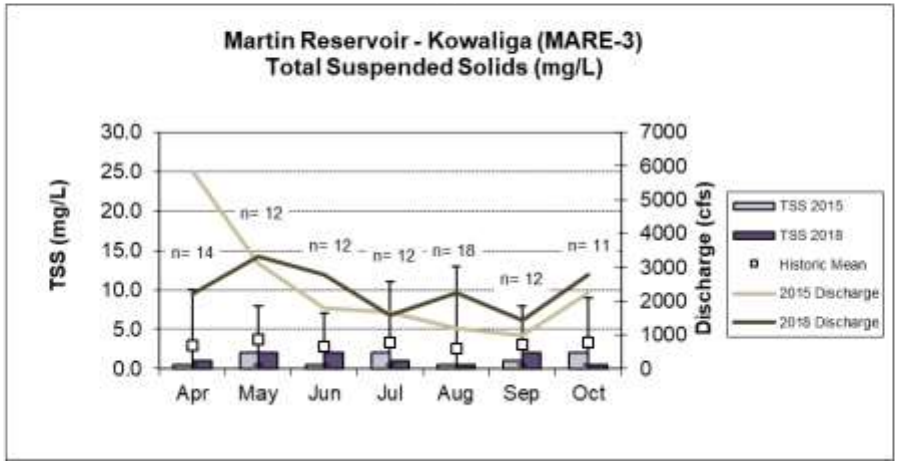
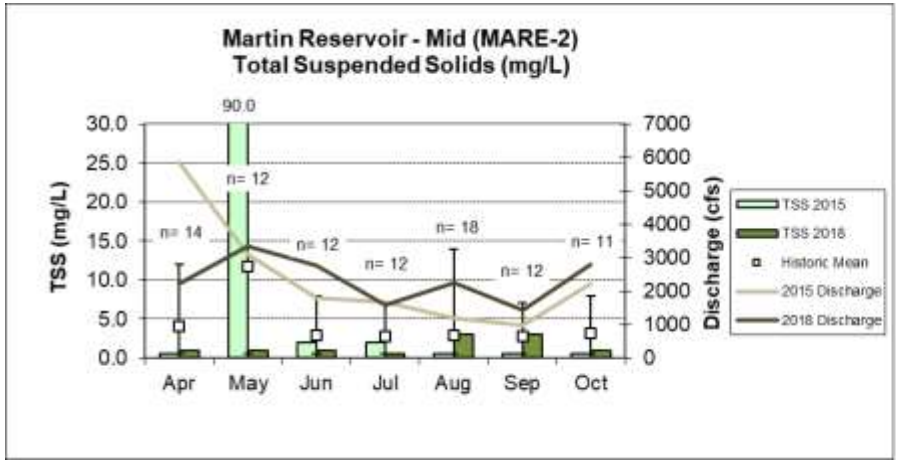


Figure 13. Monthly TSS concentrations measured at mid and lower stations in Martin Reservoir, April-October 2015 and 2018 vs. average monthly discharge. Monthly discharge acquired from Alabama Power at Martin Reservoir Dam. Each bar graph depicts monthly changes in each station. The historic mean (1992-2018) and min/max ranges are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.



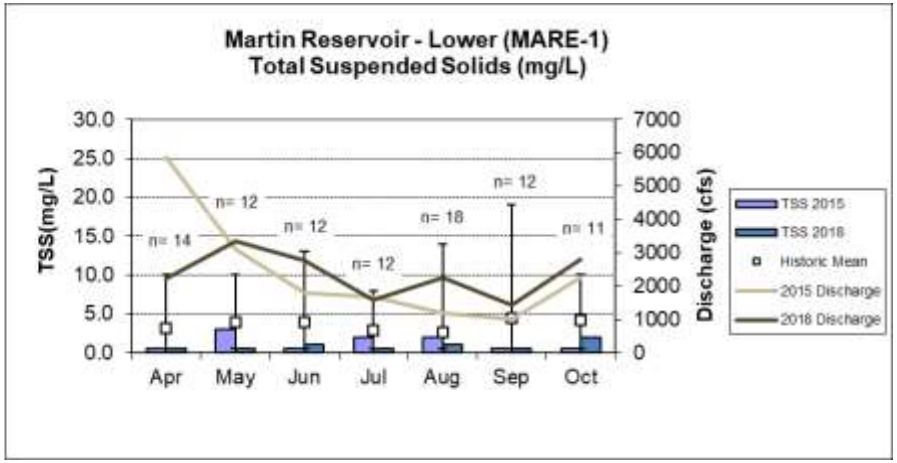


Table 2. Algal growth potential test (AGPT) results, Martin Reservoir, expressed as mean Maximum Standing Crop (MSC) dry weights of *Selenastrum capricornutum* in mg/L and limiting nutrient status. MSC values below 5 mg/L are considered to be protective in reservoirs and lakes (Raschke and Schultz 1987).

Station	Hillabee (MARE-6)		Upstream 280 (MARE-5)		Upper (MARE-4)		Kowliga (MARE-3)		Mid (MARE-2)		Lower (MARE-1)	
	Control Mean MSC	Limiting Nutrient	Control Mean MSC	Limiting Nutrient	Control Mean MSC	Limiting Nutrient	Control Mean MSC	Limiting Nutrient	Control Mean MSC	Limiting Nutrient	Control Mean MSC	Limiting Nutrient
1997	---	---	---	---	2.6	Phosphorus	1.58	Co-limiting	1.83	Co-limiting	1.75	Phosphorus
2000	---	---	3.2	Phosphorus	3.01	Nitrogen	1.63	Phosphorus	*	*	1.73	Phosphorus
Apr 2004	---	---	3.63	Phosphorus	3.24	Phosphorus	2.05	Phosphorus	2.05	Phosphorus	1.92	Phosphorus
May 2004	---	---	3.79	Phosphorus	3.01	Phosphorus	1.85	Phosphorus	1.97	Phosphorus	1.41	Phosphorus
Jun 2004	---	---	3.59	Phosphorus	3.38	Phosphorus	2.36	Phosphorus	2.39	Phosphorus	2.43	Phosphorus
Jul 2004	---	---	2.7	Phosphorus	1.94	Phosphorus	1.27	Phosphorus	1.56	Phosphorus	1.38	Phosphorus
Aug 2004	---	---	4.44	Phosphorus	2.97	Co-limiting	1.83	Co-limiting	2.61	Co-limiting	2.43	Co-limiting
Sep 2004	---	---	4.28	Phosphorus	4.04	Co-limiting	1.86	Phosphorus	1.9	Phosphorus	1.73	Phosphorus
Oct 2004	---	---	5.4	Phosphorus	4.43	Co-limiting	3.25	Phosphorus	3.34	Phosphorus	3.12	Phosphorus
2005	---	---	4.26	Phosphorus	3.5	Co-limiting	2.78	Phosphorus	2.89	Phosphorus	2.99	Phosphorus
2010	3.47	Nitrogen	2.25	Phosphorus	---	---	---	---	---	---	---	---
2015	3.66	Co-limiting	2.72	Phosphorus	2.44	Phosphorus	1.66	Phosphorus	1.66	Phosphorus	1.97	Phosphorus

*Lost/damaged sample

Table 2. (Continued)

Station	Blue (MARE-11)		Sandy (MARE-10)		Manoy (MARE-9)		Elkahatchee (MARE-8)		Coley (MARE-7)	
	Control Mean MSC	Limiting Nutrient	Control Mean MSC	Limiting Nutrient	Control Mean MSC	Limiting Nutrient	Control Mean MSC	Limiting Nutrient	Control Mean MSC	Limiting Nutrient
2015	2.56	Phosphorus	3.44	Phosphorus	2.31	Phosphorus	2.58	Co-limiting	24.56	Nitrogen

Figure 14. Monthly DO concentrations at 1.5 m (5 ft) for Martin Reservoir stations collected April-October 2015. ADEM Water Quality Criteria pertaining to reservoir waters require a minimum DO concentration of 5.0 mg/L at this depth (ADEM 2010).

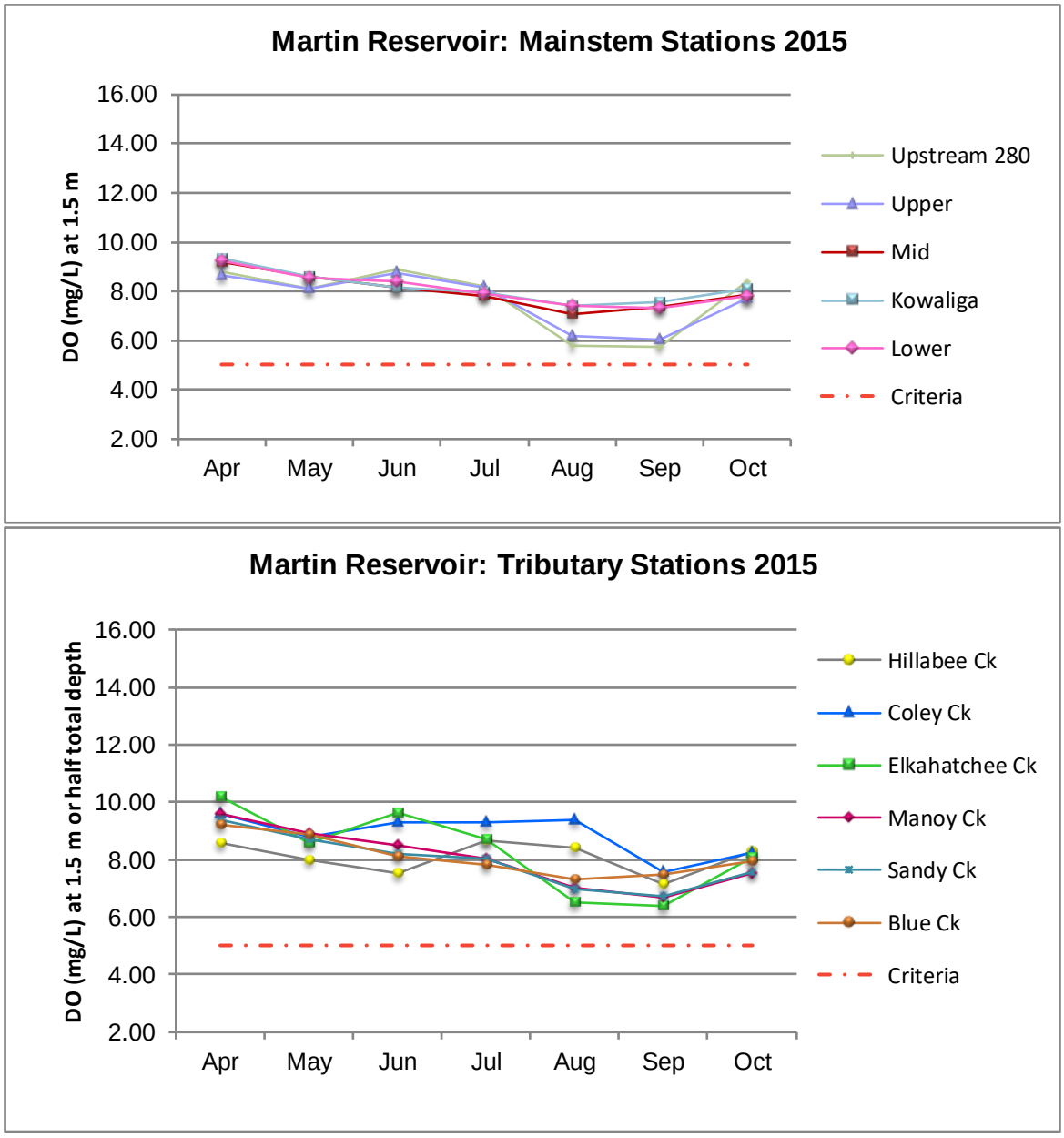


Figure 15. Monthly DO concentrations at 1.5 m (5 ft) for Martin Reservoir stations collected April-October 2018. ADEM Water Quality Criteria pertaining to reservoir waters require a minimum DO concentration of 5.0 mg/L at this depth (ADEM 2010).

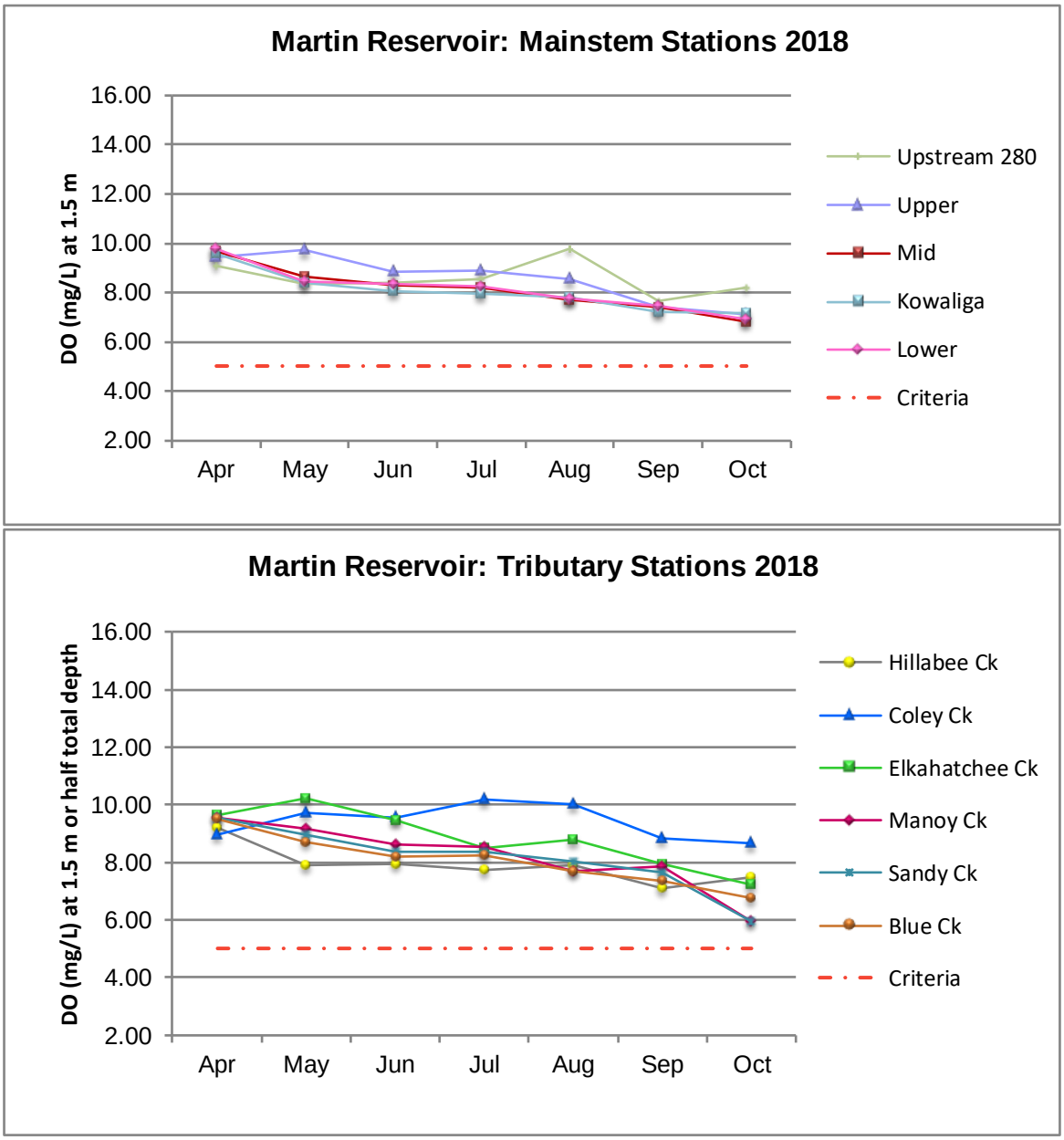


Figure 16. Monthly depth profiles of dissolved oxygen, temperature, and conductivity in the upper Martin Reservoir station, April-October 2015.

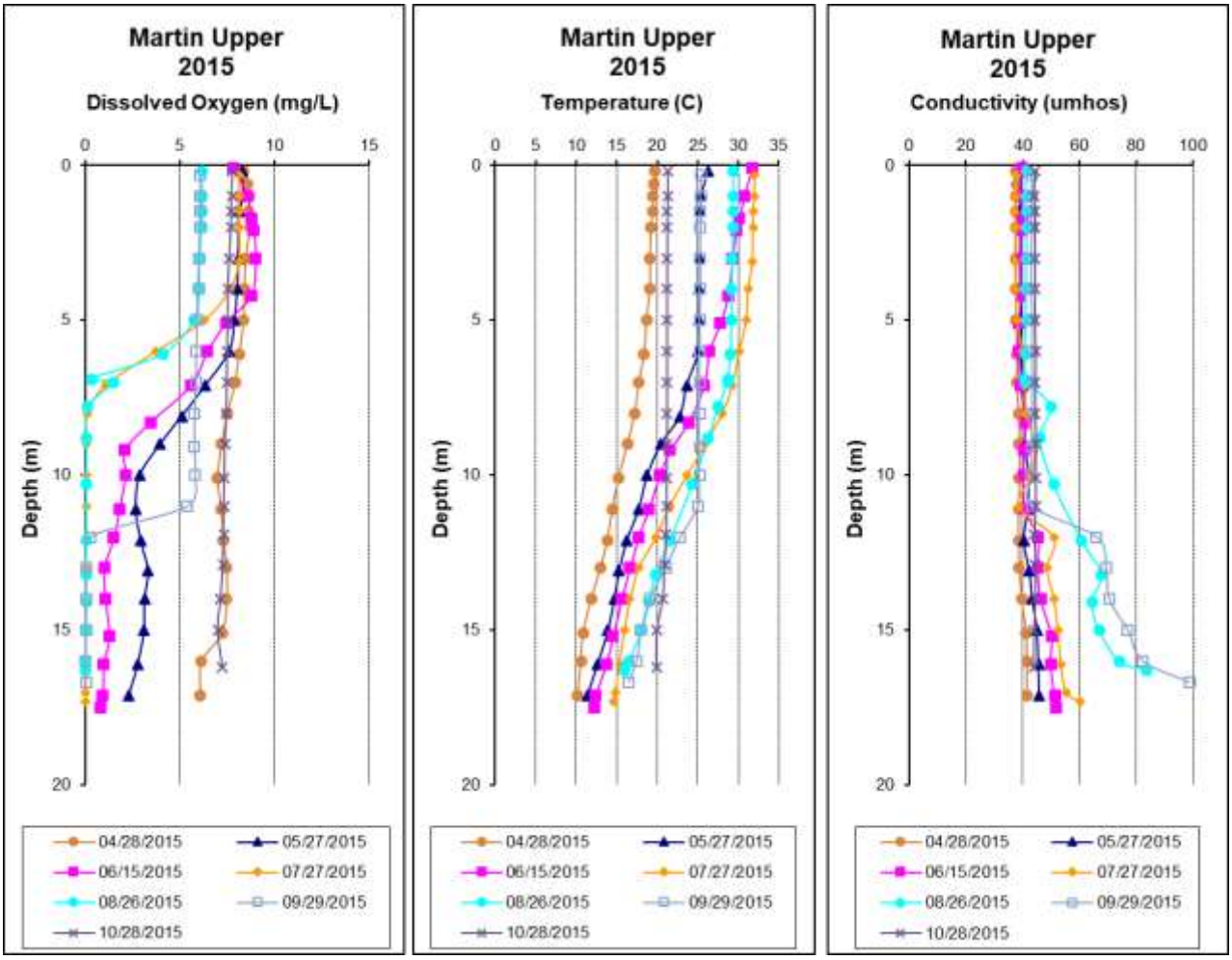


Figure 17. Monthly depth profiles of dissolved oxygen, temperature, and conductivity in the lower Martin Reservoir station, April-October 2015.

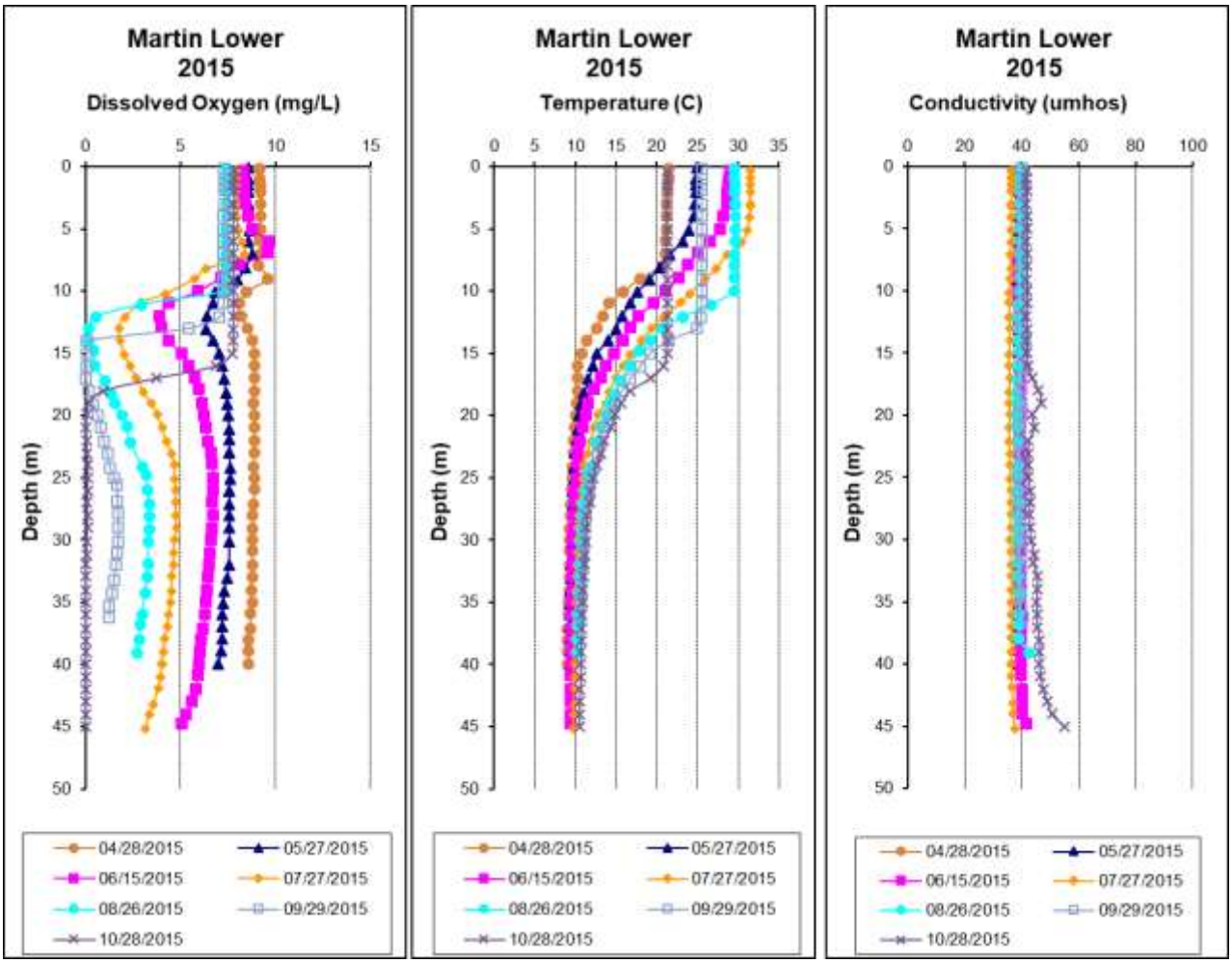


Figure 18. Monthly depth profiles of dissolved oxygen, temperature, and conductivity in the upper Martin Reservoir station, April-October 2018.

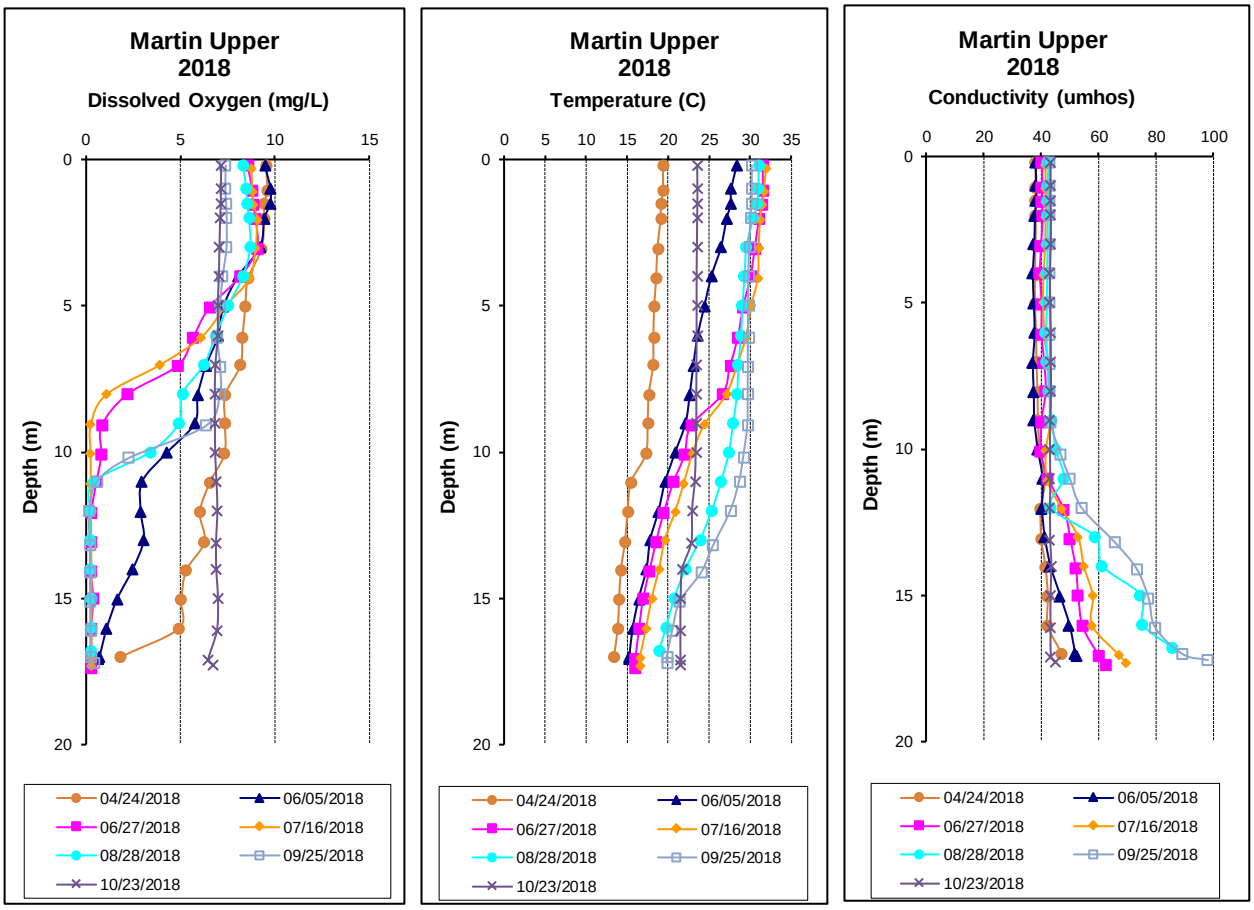


Figure 19. Monthly depth profiles of dissolved oxygen, temperature, and conductivity in the lower Martin Reservoir station, April-October 2018.

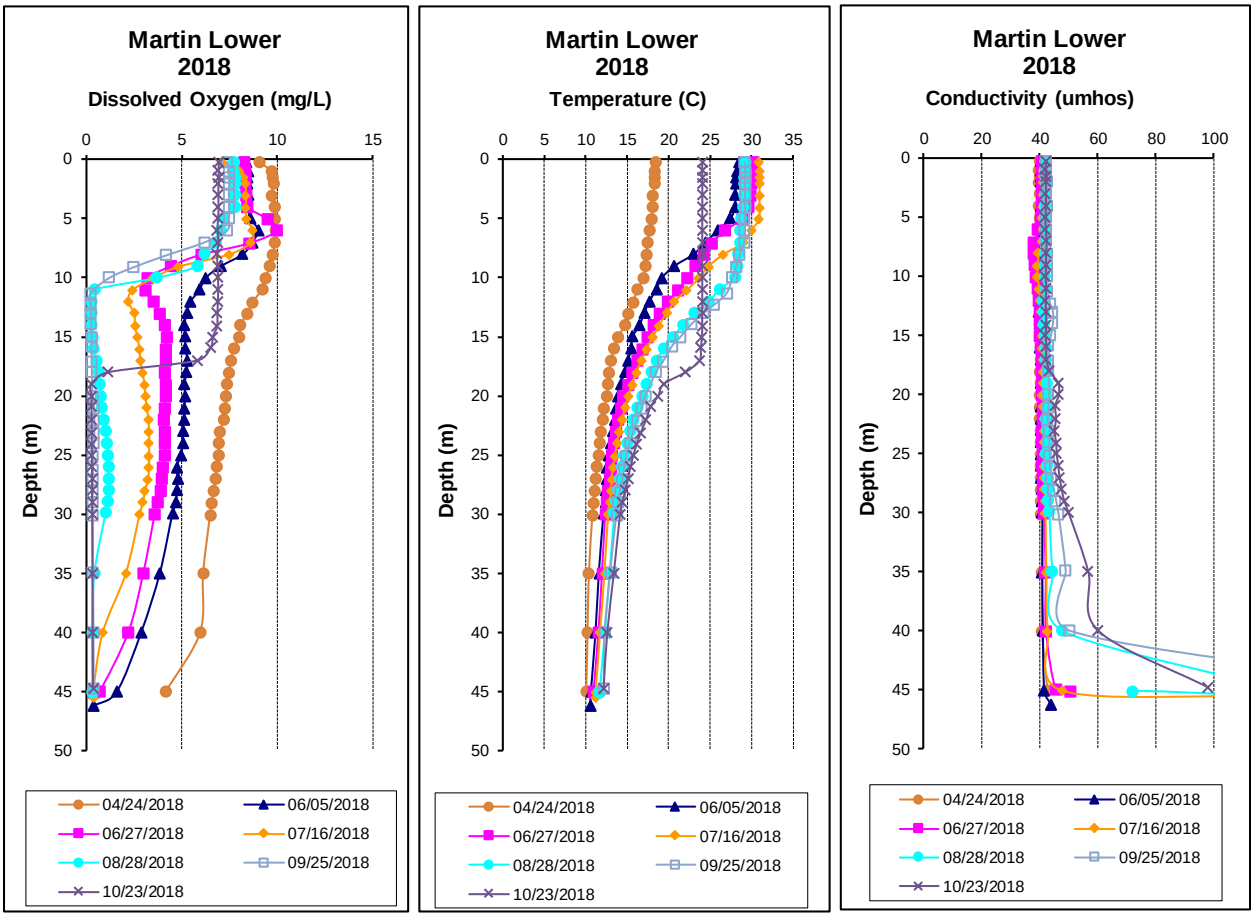
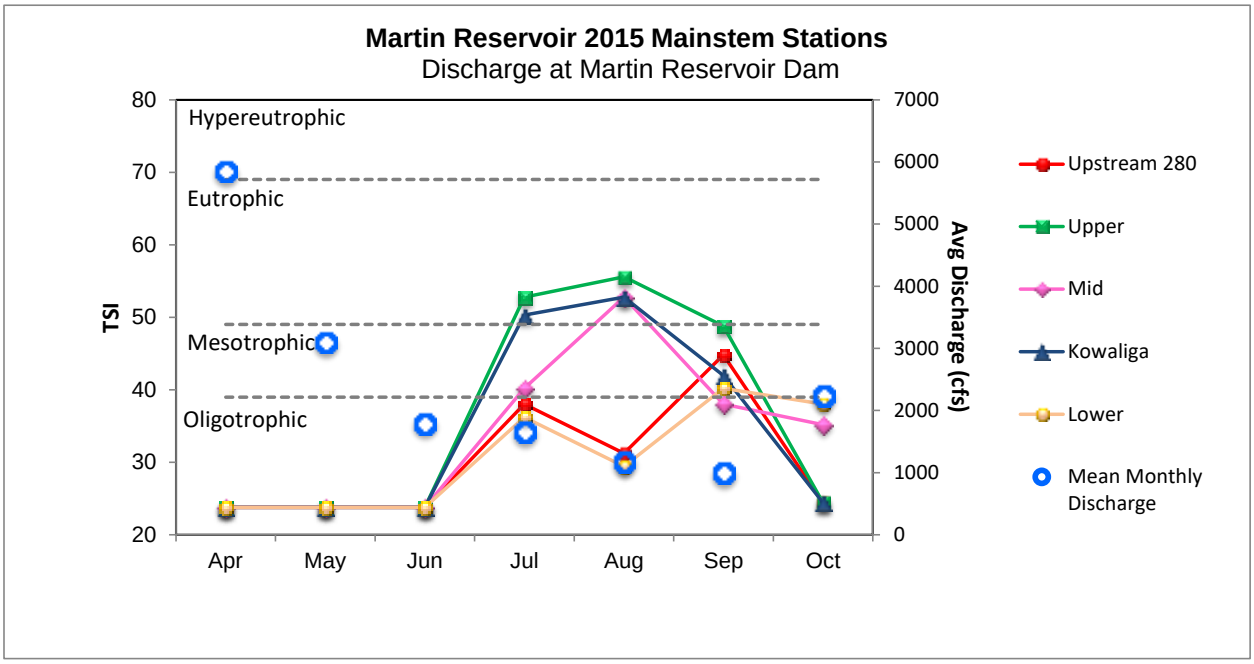


Figure 20. Monthly TSI values calculated for mainstem and tributary Martin Reservoir stations in 2015 using chl *a* concentrations and Carlson's Trophic State Index calculation. Monthly discharge acquired from Alabama Power at Martin Dam.



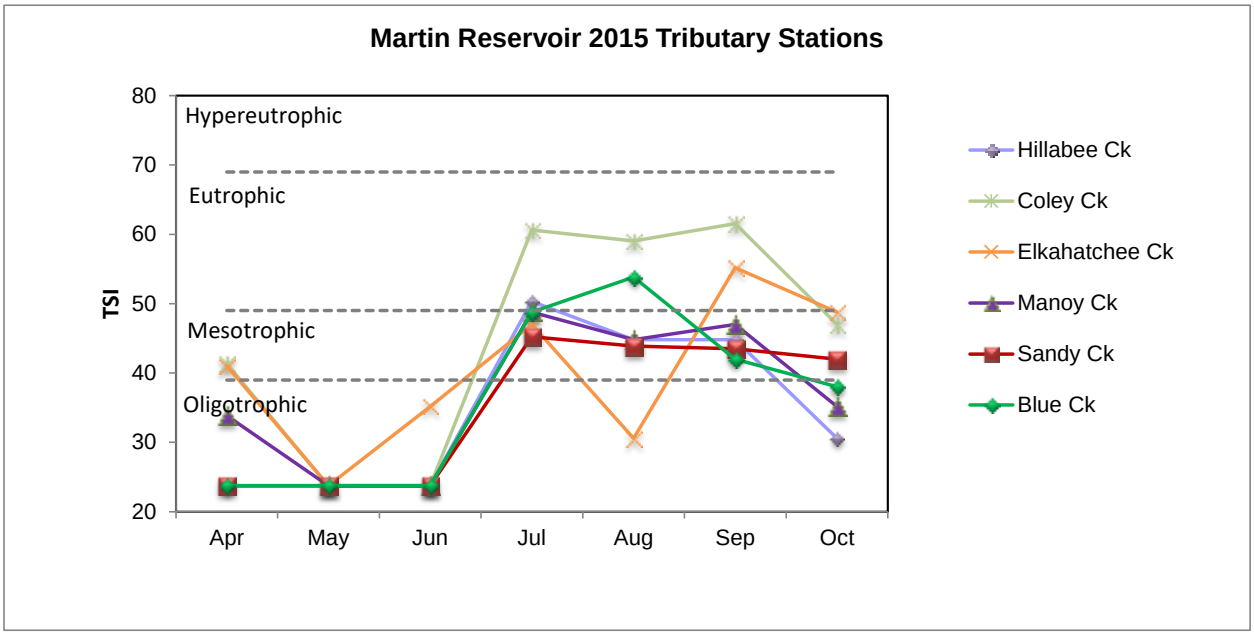
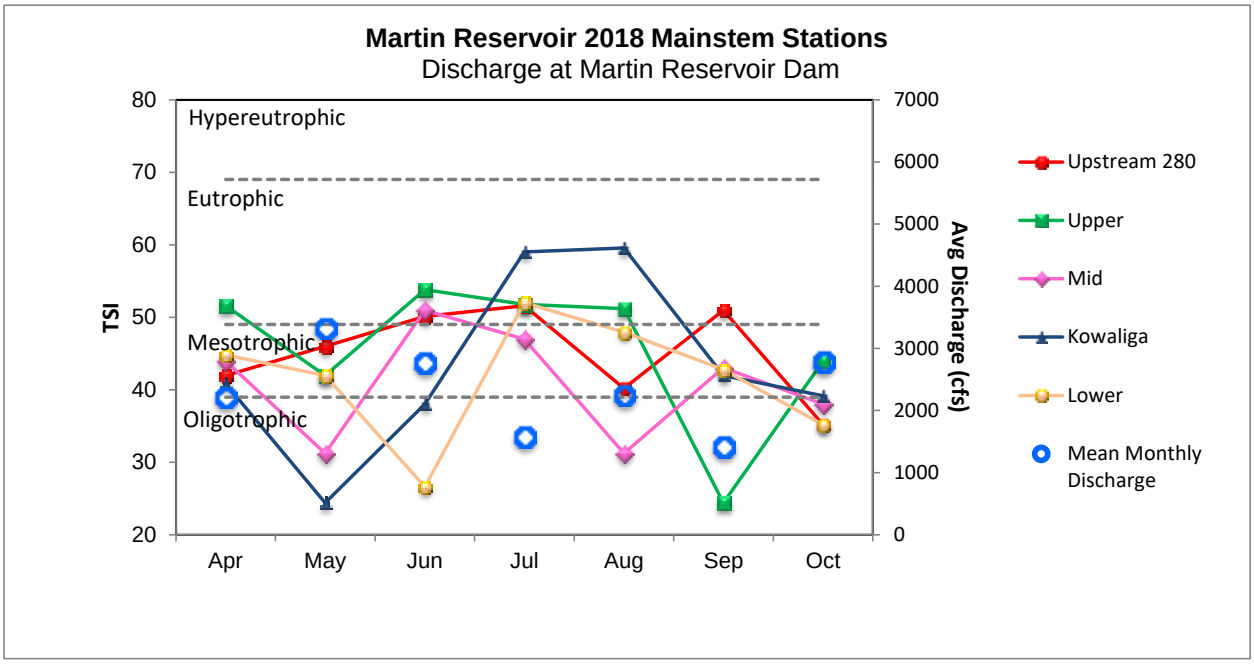
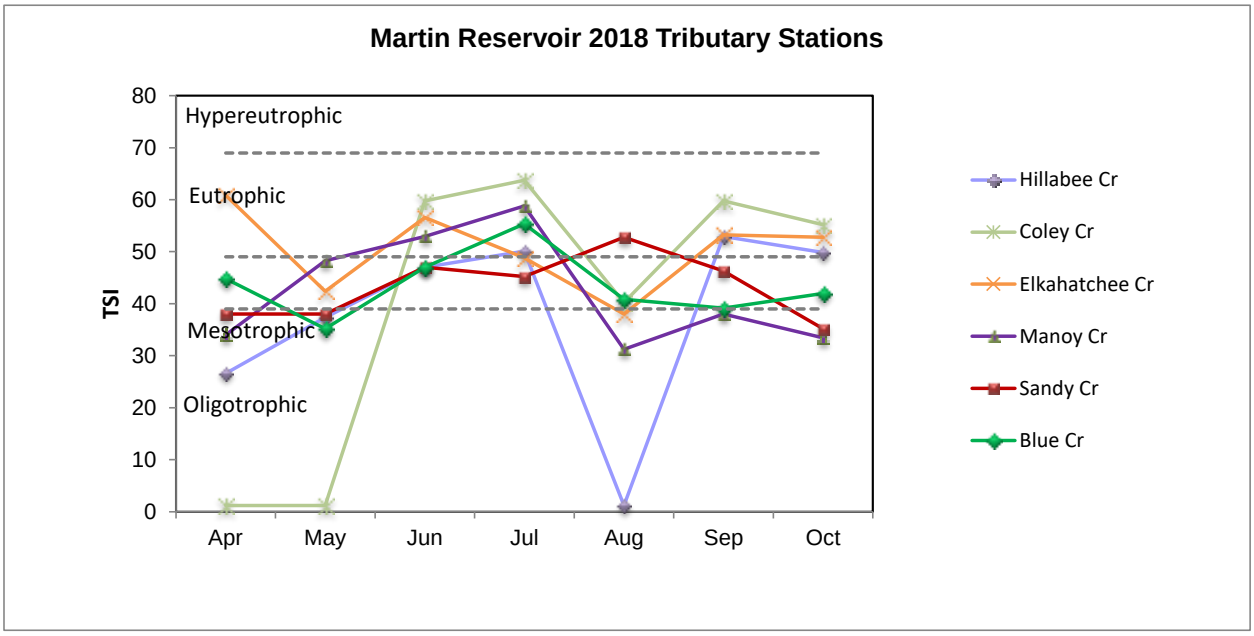


Figure 21. Monthly TSI values calculated for mainstem and tributary Martin Reservoir stations in 2018 using chl *a* concentrations and Carlson's Trophic State Index calculation. Monthly discharge acquired from Alabama Power at Martin Dam.





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APPENDIX

Appendix Table 1. Summary of water quality data collected April-October 2015. Minimum (Min) and maximum (Max) values calculated using minimum detection limits (MDL) when results were less than this value. Median (Med), mean, and standard deviations (SD) values were calculated by multiplying the MDL by 0.5 when results were less than this value.

Station	Parameter	N	Min	Max	Med	Mean	SD
MARE-1	**Physical**						
	Turbidity (NTU)	7	1.4	2.1	1.6	1.6	0.3
	Total Dissolved Solids (mg/L)[J]	7	4.0	57.0	20.0	23.9	18.5
	Total Suspended Solids (mg/L)	7	< 1.0	3.0	0.5	1.3	1.0
	Hardness (mg/L)	4	12.4	12.9	12.6	12.6	0.2
	Alkalinity (mg/L)	7	11.8	13.9	13.1	13.0	0.9
	Photic Zone (m)	7	9.22	17.09	9.98	10.94	2.80
	Secchi (m)	7	3.15	4.45	3.74	3.75	0.52
	Bottom Depth (m)	7	36.3	45.2	40.0	41.5	3.5
	Chemical						
	Ammonia Nitrogen (mg/L)[J]	7	< 0.010	0.179	0.020	0.077	0.083
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.001	0.080	0.002	0.020	0.032
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.064	0.421	0.218	0.242	0.166
	Total Nitrogen (mg/L)[J]	7	< 0.033	0.423	0.298	0.262	0.157
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.002	0.005	0.003	0.003	0.002
	Total Phosphorus (mg/L)[J]	7	0.005	0.010	0.006	0.007	0.002
	CBOD-5 (mg/L)[J]	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.2	2.4	2.3	2.3	0.1
	Biological						
	Chlorophyll a (mg/m^3)	7	< 0.89	2.67	0.89	1.28	0.90
	E. coli (MPN/DL)[J]	3	1	1	1	1	0
MARE-2	**Physical**						
	Turbidity (NTU)	7	1.6	2.4	2.1	1.9	0.3
	Total Dissolved Solids (mg/L)[J]	7	< 1.0	37.0	19.0	20.1	14.9
	Total Suspended Solids (mg/L)	7	< 1.0	90.0	0.5	13.7	33.6
	Hardness (mg/L)	4	12.1	13.1	12.6	12.6	0.5
	Alkalinity (mg/L)	7	11.4	14.1	12.9	12.8	1.1
	Photic Zone (m)	7	7.35	15.12	9.44	10.44	2.69
	Secchi (m)	7	2.36	4.46	3.48	3.33	0.70
	Bottom Depth (m)	7	36.2	41.6	40.0	39.5	2.0
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.010	0.204	0.020	0.074	0.086
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.001	0.114	0.003	0.034	0.054
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.064	0.404	0.256	0.195	0.159
	Total Nitrogen (mg/L)[J]	7	< 0.033	0.408	0.259	0.229	0.160
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.002	0.005	0.002	0.003	0.001
	Total Phosphorus (mg/L)[J]	7	0.004	0.010	0.007	0.007	0.002
	CBOD-5 (mg/L)[J]	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.3	2.4	2.3	2.3	0.0
	Biological						
	Chlorophyll a (mg/m^3)	7	< 1.00	9.61	1.60	2.50	3.25
	E. coli (MPN/DL)[J]	3	1	1	1	1	0

Appendix Table 1. (continued)

Station	Parameter	N	Min	Max	Med	Mean	SD
MARE-3	**Physical**						
	Turbidity (NTU)	7	1.1	2.1	1.7	1.7	0.3
	Total Dissolved Solids (mg/L)[J]	7	5.0	45.0	27.0	25.9	17.2
	Total Suspended Solids (mg/L)	7	< 1.0	2.0	1.0	1.2	0.8
	Hardness (mg/L)	4	11.9	13.1	12.4	12.5	0.5
	Alkalinity (mg/L)	7	12.2	14.1	13.3	13.1	0.8
	Photic Zone (m)	7	7.16	12.76	10.59	10.36	1.78
	Secchi (m)	7	2.96	4.40	3.19	3.31	0.50
	Bottom Depth (m)	7	24.9	26.8	25.9	25.7	0.8
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.010	0.174	0.024	0.052	0.066
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.001	0.061	0.001	0.013	0.022
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.064	0.720	0.112	0.215	0.259
	Total Nitrogen (mg/L)[J]	7	< 0.033	0.721	0.173	0.228	0.253
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.002	0.004	0.004	0.003	0.001
	Total Phosphorus (mg/L)[J]	7	0.005	0.008	0.006	0.006	0.001
	CBOD-5 (mg/L)[J]	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.3	2.4	2.3	2.3	0.0
	Biological						
	Chlorophyll a (mg/m³)	7	< 0.53	9.61	0.53	3.19	3.84
	E. coli (MPN/DL)[J]	3	1	1	1	1	0
MARE-4	**Physical**						
	Turbidity (NTU)	7	2.5	11.5	3.2	4.2	3.2
	Total Dissolved Solids (mg/L)	7	4.0	50.0	25.0	23.4	17.8
	Total Suspended Solids (mg/L)	7	< 1.0	5.0	2.0	2.4	1.7
	Hardness (mg/L)	4	11.9	13.4	12.5	12.6	0.7
	Alkalinity (mg/L)	7	10.7	14.9	13.4	13.2	1.7
	Photic Zone (m)	7	1.33	9.48	5.43	5.43	2.37
	Secchi (m)	7	0.90	2.46	1.97	1.92	0.52
	Bottom Depth (m)	7	16.2	17.5	17.1	16.9	0.5
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.010	0.281	0.022	0.081	0.109
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	0.001	0.175	0.010	0.037	0.064
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.064	0.733	0.198	0.302	0.288
	Total Nitrogen (mg/L)[J]	7	< 0.040	0.743	0.338	0.339	0.278
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.002	0.005	0.003	0.003	0.001
	Total Phosphorus (mg/L)[J]	7	0.005	0.018	0.010	0.011	0.004
	CBOD-5 (mg/L)[J]	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.3	2.6	2.4	2.4	0.1
	Biological						
	Chlorophyll a (mg/m³)	7	< 0.53	12.80	0.53	4.41	5.20
	E. coli (MPN/DL)[J]	2	1	3	2	2	2

Appendix Table 1. (continued)

Station	Parameter	N	Min	Max	Med	Mean	SD
MARE-5	**Physical**						
	Turbidity (NTU)	7	5.9	13.2	7.0	8.5	2.9
	Total Dissolved Solids (mg/L)	7	10.0	37.0	30.0	26.0	10.6
	Total Suspended Solids (mg/L)	7	1.0	10.0	6.0	5.0	3.0
	Hardness (mg/L)	4	11.0	13.7	12.2	12.3	1.2
	Alkalinity (mg/L)	7	10.7	15.5	13.3	13.0	2.1
	Photic Zone (m)	7	2.75	5.68	3.98	4.02	1.24
	Secchi (m)	7	0.90	1.68	1.34	1.30	0.31
	Bottom Depth (m)	7	4.3	9.0	8.1	7.6	1.6
	Chemical						
	Ammonia Nitrogen (mg/L)[J]	7	< 0.010	0.244	0.023	0.068	0.089
	Nitrate+Nitrite Nitrogen (mg/L)	7	0.040	0.179	0.087	0.097	0.048
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.064	0.547	0.207	0.237	0.174
	Total Nitrogen (mg/L)[J]	7	< 0.156	0.613	0.310	0.334	0.156
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.002	0.005	0.003	0.003	0.001
	Total Phosphorus (mg/L)	7	0.011	0.020	0.014	0.015	0.003
	CBOD-5 (mg/L)[J]	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.2	2.8	2.6	2.5	0.2
	Biological						
	Chlorophyll a (mg/m³)	7	< 0.53	4.27	0.53	1.36	1.42
	E. coli (MPN/DL)[J]	3	1	4	2	2	2
MARE-6	**Physical**						
	Turbidity (NTU)	7	7.4	29.1	10.6	13.4	8.1
	Total Dissolved Solids (mg/L)	7	6.0	44.0	29.0	26.1	16.6
	Total Suspended Solids (mg/L)	7	1.0	101.0	6.0	20.7	35.9
	Hardness (mg/L)	4	10.8	12.7	11.7	11.7	0.8
	Alkalinity (mg/L)	7	11.1	15.8	13.8	13.6	1.6
	Photic Zone (m)	7	1.90	3.80	3.10	2.93	0.63
	Secchi (m)	7	0.64	1.48	1.08	1.09	0.25
	Bottom Depth (m)	7	1.9	4.0	3.6	3.2	0.8
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.010	0.223	0.015	0.056	0.082
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	0.004	0.105	0.023	0.044	0.042
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.064	0.439	0.316	0.229	0.159
	Total Nitrogen (mg/L)[J]	7	< 0.124	0.443	0.330	0.273	0.122
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.003	0.008	0.004	0.005	0.002
	Total Phosphorus (mg/L)	7	0.016	0.024	0.021	0.020	0.003
	CBOD-5 (mg/L)[J]	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	1.8	4.2	2.8	2.8	0.8
	Biological						
	Chlorophyll a (mg/m³)	7	< 0.10	7.48	0.50	2.51	2.86
	E. coli (MPN/DL)[J]	3	1	16	9	9	8

Appendix Table 1. (continued)

Station	Parameter	N	Min	Max	Med	Mean	SD
MARE-7	**Physical**						
	Turbidity (NTU)	7	4.4	10.0	6.7	7.3	1.9
	Total Dissolved Solids (mg/L)	7	2.0	50.0	29.0	29.0	17.0
	Total Suspended Solids (mg/L)	7	2.0	10.0	5.0	6.0	2.6
	Hardness (mg/L)	4	12.1	15.2	13.5	13.6	1.4
	Alkalinity (mg/L)	7	11.8	16.7	14.4	13.9	1.9
	Photic Zone (m)	7	1.43	3.30	2.50	2.42	0.65
	Secchi (m)	7	0.72	2.14	1.02	1.33	0.52
	Bottom Depth (m)	7	1.8	3.3	2.6	2.6	0.5
	Chemical						
	Ammonia Nitrogen (mg/L)[J]	7	< 0.010	0.182	0.012	0.060	0.078
	Nitrate+Nitrite Nitrogen (mg/L)	7	0.025	0.678	0.168	0.261	0.237
	Total Kjeldahl Nitrogen (mg/L)[J]	7	0.114	1.720	0.584	0.686	0.557
	Total Nitrogen (mg/L)[J]	7	0.349	2.398	0.752	0.948	0.753
	Dis Reactive Phosphorus (mg/L)[J]	7	0.003	0.028	0.005	0.011	0.011
	Total Phosphorus (mg/L)	7	0.019	0.075	0.027	0.038	0.020
	CBOD-5 (mg/L)[J]	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.5	5.1	2.9	3.4	1.0
	Biological						
	Chlorophyll a (mg/m³)	7	< 1.00	23.50	5.34	10.35	10.24
	E. coli (MPN/DL)[J]	3	1	10	3	5	5
MARE-8	**Physical**						
	Turbidity (NTU)	7	3.0	5.2	3.7	4.0	0.8
	Total Dissolved Solids (mg/L)[J]	7	12.0	39.0	24.0	25.9	10.8
	Total Suspended Solids (mg/L)[J]	7	< 1.0	6.0	3.0	2.6	2.0
	Hardness (mg/L)	4	13.1	14.6	13.9	13.9	0.7
	Alkalinity (mg/L)	7	14.5	16.8	15.5	15.6	0.9
	Photic Zone (m)	7	2.20	7.44	4.86	5.03	1.58
	Secchi (m)	7	1.46	2.29	1.83	1.82	0.29
	Bottom Depth (m)	7	8.1	10.1	9.4	9.3	0.6
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.010	0.206	0.005	0.066	0.086
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.001	0.007	0.003	0.003	0.002
	Total Kjeldahl Nitrogen (mg/L)	7	0.160	1.140	0.362	0.460	0.347
	Total Nitrogen (mg/L)[J]	7	< 0.163	1.141	0.369	0.463	0.346
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.002	0.006	0.003	0.003	0.001
	Total Phosphorus (mg/L)	7	0.011	0.018	0.014	0.015	0.003
	CBOD-5 (mg/L)[J]	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.4	2.6	2.5	2.5	0.0
	Biological						
	Chlorophyll a (mg/m³)	7	< 0.10	12.30	2.90	4.16	4.30
	E. coli (MPN/DL)[J]	3	1	2	2	2	1

Appendix Table 1. (continued)

Station	Parameter	N	Min	Max	Med	Mean	SD
MARE-9	**Physical**						
	Turbidity (NTU)	7	1.8	2.6	2.2	2.2	0.3
	Total Dissolved Solids (mg/L)	7	< 1.0	47.0	25.0	26.1	17.2
	Total Suspended Solids (mg/L)	7	< 1.0	3.0	2.0	1.6	0.8
	Hardness (mg/L)	4	12.0	13.9	12.8	12.9	0.8
	Alkalinity (mg/L)	7	11.8	14.7	13.7	13.5	1.1
	Photic Zone (m)	7	3.15	11.49	8.86	8.32	2.91
	Secchi (m)	7	2.00	3.56	2.56	2.64	0.49
	Bottom Depth (m)	7	14.9	17.2	16.7	16.3	1.0
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.010	0.203	0.005	0.058	0.087
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.001	0.057	0.006	0.023	0.026
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.064	0.632	0.170	0.250	0.207
	Total Nitrogen (mg/L)[J]	7	< 0.087	0.635	0.224	0.274	0.190
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.002	0.004	0.002	0.003	0.001
	Total Phosphorus (mg/L)[J]	7	0.005	0.011	0.008	0.008	0.002
	CBOD-5 (mg/L)[J]	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.2	2.5	2.4	2.4	0.1
	Biological						
	Chlorophyll a (mg/m³)	7	< 1.00	6.41	1.60	2.86	2.44
	E. coli (MPN/DL)[J]	3	1	8	1	3	4
MARE-10	**Physical**						
	Turbidity (NTU)	7	1.4	2.2	1.8	1.8	0.3
	Total Dissolved Solids (mg/L)	7	1.0	41.0	27.0	25.3	14.6
	Total Suspended Solids (mg/L)	7	< 1.0	3.0	1.0	1.6	1.1
	Hardness (mg/L)	4	11.7	14.3	13.1	13.0	1.1
	Alkalinity (mg/L)	7	12.1	15.4	13.9	13.8	1.4
	Photic Zone (m)	7	7.19	13.40	8.96	9.42	2.08
	Secchi (m)	7	2.31	4.82	3.15	3.39	0.98
	Bottom Depth (m)	7	22.7	26.3	25.3	24.7	1.2
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.010	0.244	0.005	0.054	0.092
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	0.001	0.119	0.010	0.026	0.042
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.064	0.879	0.244	0.334	0.317
	Total Nitrogen (mg/L)[J]	7	< 0.042	0.884	0.363	0.360	0.308
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.002	0.004	0.002	0.003	0.001
	Total Phosphorus (mg/L)[J]	7	0.007	0.011	0.009	0.009	0.001
	CBOD-5 (mg/L)[J]	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.3	2.5	2.3	2.3	0.1
	Biological						
	Chlorophyll a (mg/m³)	7	< 1.00	4.45	3.20	2.40	1.81
	E. coli (MPN/DL)[J]	3	1	1	1	1	0

Appendix Table 1. (continued)

Station	Parameter	N	Min	Max	Med	Mean	SD
MARE-11	**Physical**						
	Turbidity (NTU)	7	1.4	2.9	2.0	2.0	0.6
	Total Dissolved Solids (mg/L)	7	5.0	41.0	25.0	26.0	12.0
	Total Suspended Solids (mg/L)	7	< 1.0	3.0	0.5	0.9	0.9
	Hardness (mg/L)	4	11.3	13.1	12.2	12.2	0.9
	Alkalinity (mg/L)	7	11.8	14.2	13.3	13.0	0.1
	Photic Zone (m)	7	7.78	14.36	8.82	9.80	2.21
	Secchi (m)	7	2.65	4.35	3.25	3.32	0.60
	Bottom Depth (m)	7	24.4	29.0	28.1	27.5	1.7
	Chemical						
	Ammonia Nitrogen (mg/L)[J]	7	< 0.010	0.228	0.020	0.064	0.083
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.001	0.125	0.004	0.027	0.045
	Total Kjeldahl Nitrogen (mg/L)[J]	7	0.065	1.200	0.185	0.456	0.478
	Total Nitrogen (mg/L)[J]	7	< 0.084	1.201	0.234	0.482	0.458
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.002	0.004	0.003	0.003	0.001
	Total Phosphorus (mg/L)[J]	7	0.005	0.010	0.008	0.008	0.002
	CBOD-5 (mg/L)[J]	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.3	2.4	2.4	2.3	0.0
	Biological						
	Chlorophyll a (mg/m^3)	7	< 1.00	10.70	2.14	3.42	3.86
	E. coli (MPN/DL)[J]	3	1	1	1	1	0

J=one or more of the values provided are estimated; < = Actual value is less than the detection limit

Appendix Table 2. Summary of water quality data collected April-October 2018. Minimum (Min) and maximum (Max) values calculated using minimum detection limits (MDL) when results were less than this value. Median (Med), mean, and standard deviations (SD) values were calculated by multiplying the MDL by 0.5 when results were less than this value.

Station	Parameter	N	Min	Max	Med	Mean	SD
MARE-1	**Physical**						
	Turbidity (NTU)	7	1.2	2.2	1.6	1.5	0.3
	Total Dissolved Solids (mg/L)	7	21.0	31.0	26.0	26.1	3.7
	Total Suspended Solids (mg/L)	7	< 1.0	2.0	0.5	0.9	0.6
	Hardness (mg/L)	4	11.0	13.9	12.0	12.2	1.2
	Alkalinity (mg/L)	7	12.5	15.8	12.9	13.3	1.2
	Photic Zone (m)	7	7.46	11.46	9.35	9.60	1.37
	Secchi (m)	7	3.62	4.73	3.82	4.06	0.48
	Bottom Depth (m)	7	44.8	46.2	45.1	45.2	0.5
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.007	0.016	0.004	0.004	0.002
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.004	0.102	0.002	0.021	0.037
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.077	0.412	0.220	0.213	0.138
	Total Nitrogen (mg/L)[J]	7	< 0.040	0.514	0.239	0.233	0.162
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.004	0.004	0.002	0.002	0.001
	Total Phosphorus (mg/L)[J]	7	0.006	0.011	0.008	0.008	0.002
	CBOD-5 (mg/L)	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.3	2.4	2.4	2.4	0.0
	Biological						
	Chlorophyll a (mg/m^3)	7	0.67	8.90	3.47	4.00	2.75
	E. coli (MPN/DL)[J]	4	1	8	3	3	3
MARE-2	**Physical**						
	Turbidity (NTU)	7	1.1	1.8	1.6	1.6	0.3
	Total Dissolved Solids (mg/L)	7	< 1.0	31.0	27.0	23.8	10.7
	Total Suspended Solids (mg/L)	7	< 1.0	3.0	1.0	1.5	1.0
	Hardness (mg/L)	4	10.9	14.1	11.8	12.2	1.4
	Alkalinity (mg/L)	7	12.2	13.4	12.9	12.9	0.4
	Photic Zone (m)	7	6.76	9.85	8.71	8.73	1.06
	Secchi (m)	7	2.82	4.79	3.53	3.85	0.71
	Bottom Depth (m)	7	41.2	42.3	42.2	42.0	0.4
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.007	0.016	0.004	0.004	0.002
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.004	0.136	0.007	0.031	0.049
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.077	0.244	0.100	0.099	0.074
	Total Nitrogen (mg/L)[J]	7	< 0.040	0.380	0.102	0.130	0.118
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.004	0.004	0.002	0.003	0.001
	Total Phosphorus (mg/L)[J]	7	0.005	0.012	0.009	0.009	0.002
	CBOD-5 (mg/L)	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.3	2.5	2.4	2.4	0.0
	Biological						
	Chlorophyll a (mg/m^3)	7	1.07	8.01	3.56	3.59	2.50
	E. coli (MPN/DL)[J]	4	1	1	1	1	0

Appendix Table 2. (continued)

Station	Parameter	N	Min	Max	Med	Mean	SD
MARE-3	**Physical**						
	Turbidity (NTU)	7	1.4	2.4	1.6	1.7	0.3
	Total Dissolved Solids (mg/L)	7	20.0	38.0	29.0	29.0	5.5
	Total Suspended Solids (mg/L)	7	< 1.0	2.0	1.0	1.3	0.7
	Hardness (mg/L)	4	11.2	14.1	12.1	12.4	1.2
	Alkalinity (mg/L)	7	11.9	13.7	13.3	13.1	0.6
	Photic Zone (m)	7	8.68	11.19	10.02	9.84	0.85
	Secchi (m)	7	3.41	4.46	4.00	3.98	0.34
	Bottom Depth (m)	7	26.1	28.7	27.7	27.8	0.9
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.007	0.016	0.004	0.004	0.002
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.004	0.060	0.002	0.013	0.021
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.077	0.342	0.100	0.160	0.111
	Total Nitrogen (mg/L)[J]	7	< 0.040	0.344	0.102	0.172	0.121
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.004	0.004	0.002	0.002	0.001
	Total Phosphorus (mg/L)[J]	7	0.006	0.011	0.009	0.009	0.002
	CBOD-5 (mg/L)	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.3	2.4	2.4	2.4	0.0
	Biological						
	Chlorophyll a (mg/m³)	7	0.53	19.20	2.85	6.93	8.09
	E. coli (MPN/DL)[J]	4	1	2	1	1	1
MARE-4	**Physical**						
	Turbidity (NTU)	7	2.1	4.9	2.9	3.0	1.0
	Total Dissolved Solids (mg/L)	7	21.0	33.0	28.0	27.0	4.5
	Total Suspended Solids (mg/L)[J]	7	< 1.0	6.0	3.0	2.6	2.0
	Hardness (mg/L)	4	10.7	13.7	11.4	11.8	1.3
	Alkalinity (mg/L)	7	11.1	13.6	12.4	12.3	0.9
	Photic Zone (m)	7	4.53	8.07	5.91	6.16	1.35
	Secchi (m)	7	1.83	3.03	2.52	2.37	0.46
	Bottom Depth (m)	7	16.8	17.4	17.2	17.2	0.2
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.007	0.016	0.004	0.004	0.002
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.004	0.136	0.020	0.037	0.048
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.077	0.485	0.236	0.225	0.169
	Total Nitrogen (mg/L)[J]	7	< 0.040	0.547	0.256	0.262	0.194
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.004	0.005	0.002	0.002	0.001
	Total Phosphorus (mg/L)[J]	7	0.009	0.017	0.012	0.013	0.003
	CBOD-5 (mg/L)	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.2	2.7	2.5	2.5	0.1
	Biological						
	Chlorophyll a (mg/m³)	7	0.53	10.70	8.19	6.25	3.70
	E. coli (MPN/DL)[J]	4	1	1	1	1	0

Appendix Table 2. (continued)

Station	Parameter	N	Min	Max	Med	Mean	SD
MARE-5	**Physical**						
	Turbidity (NTU)	7	4.9	10.1	6.1	6.7	2.0
	Total Dissolved Solids (mg/L)[J]	7	15.0	63.0	31.0	34.0	15.7
	Total Suspended Solids (mg/L)	7	1.0	7.0	4.0	4.0	1.9
	Hardness (mg/L)	4	10.8	14.9	11.2	12.0	1.9
	Alkalinity (mg/L)	7	10.7	14.5	11.8	12.4	1.4
	Photic Zone (m)	7	3.44	3.83	3.71	3.66	0.15
	Secchi (m)	7	1.08	3.44	1.51	1.73	0.79
	Bottom Depth (m)	7	8.9	9.8	9.5	9.4	0.4
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.007	0.016	0.004	0.004	0.002
	Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.004	0.173	0.096	0.086	0.065
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.121	0.329	0.135	0.175	0.082
	Total Nitrogen (mg/L)[J]	7	< 0.137	0.362	0.247	0.260	0.090
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.004	0.005	0.002	0.003	0.001
	Total Phosphorus (mg/L)	7	0.012	0.019	0.016	0.016	0.003
	CBOD-5 (mg/L)	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.3	2.8	2.5	2.6	0.2
	Biological						
	Chlorophyll a (mg/m³)	7	1.60	8.54	4.81	5.17	2.80
	E. coli (MPN/DL)[J]	4	1	3	2	2	1
MARE-6	**Physical**						
	Turbidity (NTU)	7	11.5	18.3	13.4	14.8	2.7
	Total Dissolved Solids (mg/L)	7	15.0	56.0	33.0	34.3	13.0
	Total Suspended Solids (mg/L)[J]	7	5.0	13.0	7.0	7.9	3.0
	Hardness (mg/L)	4	11.4	14.0	11.7	12.2	1.2
	Alkalinity (mg/L)	7	11.2	14.4	13.8	13.4	1.1
	Photic Zone (m)	7	2.12	3.40	2.38	2.56	0.45
	Secchi (m)	7	0.60	1.22	0.94	0.94	0.22
	Bottom Depth (m)	7	3.3	3.9	3.5	3.6	0.2
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.007	0.016	0.004	0.004	0.002
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	0.006	0.114	0.053	0.053	0.042
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.077	0.725	0.135	0.210	0.238
	Total Nitrogen (mg/L)[J]	7	< 0.044	0.750	0.188	0.263	0.243
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.004	0.006	0.005	0.004	0.002
	Total Phosphorus (mg/L)	7	0.016	0.026	0.021	0.021	0.003
	CBOD-5 (mg/L)	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	1.8	3.1	2.5	2.4	0.5
	Biological						
	Chlorophyll a (mg/m³)	7	< 0.10	9.79	5.34	4.62	3.75
	E. coli (MPN/DL)[J]	4	1	46	10	17	20

Appendix Table 2. (continued)

Station	Parameter	N	Min	Max	Med	Mean	SD
MARE-7	**Physical**						
	Turbidity (NTU)	7	7.4	11.7	8.0	8.9	1.8
	Total Dissolved Solids (mg/L)[J]	7	18.0	43.0	32.0	31.0	9.7
	Total Suspended Solids (mg/L)[J]	7	5.0	10.0	6.0	7.0	1.8
	Hardness (mg/L)	4	12.2	15.7	13.0	13.5	1.7
	Alkalinity (mg/L)	7	13.1	14.9	13.9	13.9	0.6
	Photic Zone (m)	7	2.62	3.17	2.90	2.90	0.21
	Secchi (m)	7	1.09	1.66	1.25	1.32	0.20
	Bottom Depth (m)	7	2.7	3.2	3.2	3.1	0.2
	Chemical						
	Ammonia Nitrogen (mg/L)[J]	7	< 0.007	0.035	0.004	0.010	0.012
	Nitrate+Nitrite Nitrogen (mg/L)	7	0.093	0.339	0.283	0.234	0.090
	Total Kjeldahl Nitrogen (mg/L)	7	0.323	0.534	0.449	0.438	0.068
	Total Nitrogen (mg/L)	7	0.525	0.763	0.712	0.672	0.085
	Dis Reactive Phosphorus (mg/L)[J]	7	0.004	0.008	0.005	0.005	0.001
	Total Phosphorus (mg/L)	7	0.021	0.043	0.029	0.031	0.007
	CBOD-5 (mg/L)	7	< 2.0	2.7	1.0	1.6	0.8
	Chlorides (mg/L)	7	2.7	3.5	3.1	3.2	0.3
	Biological						
	Chlorophyll a (mg/m³)	7	< 0.10	29.40	12.30	11.95	11.48
	E. coli (MPN/DL)[J]	4	1	9	6	5	3
MARE-8	**Physical**						
	Turbidity (NTU)	7	3.0	8.0	3.5	4.3	1.8
	Total Dissolved Solids (mg/L)[J]	7	24.0	46.0	36.0	35.3	8.3
	Total Suspended Solids (mg/L)	7	< 1.0	4.0	2.0	2.4	1.4
	Hardness (mg/L)	4	11.9	15.0	13.2	13.4	1.3
	Alkalinity (mg/L)	7	14.3	16.3	15.2	15.3	0.7
	Photic Zone (m)	7	3.38	5.98	5.13	4.98	0.92
	Secchi (m)	7	1.55	2.68	1.92	1.96	0.36
	Bottom Depth (m)	7	9.4	9.9	9.6	9.6	0.2
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.007	0.016	0.004	0.004	0.002
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.004	0.040	0.002	0.008	0.014
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.200	0.422	0.309	0.298	0.112
	Total Nitrogen (mg/L)[J]	7	< 0.102	0.424	0.317	0.306	0.117
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.004	0.005	0.002	0.003	0.001
	Total Phosphorus (mg/L)[J]	7	0.009	0.022	0.014	0.015	0.005
	CBOD-5 (mg/L)	7	< 2.0	2.2	1.0	1.2	0.4
	Chlorides (mg/L)	7	2.2	2.6	2.5	2.5	0.2
	Biological						
	Chlorophyll a (mg/m³)	7	2.14	21.90	9.61	9.67	6.80
	E. coli (MPN/DL)[J]	4	1	24	2	7	12

Appendix Table 2. (continued)

Station	Parameter	N	Min	Max	Med	Mean	SD
MARE-9	**Physical**						
	Turbidity (NTU)	7	1.5	3.0	1.9	2.2	0.6
	Total Dissolved Solids (mg/L)[J]	7	26.0	60.0	31.0	34.9	11.4
	Total Suspended Solids (mg/L)	7	< 1.0	2.0	1.0	0.9	0.5
	Hardness (mg/L)	4	11.1	14.2	12.4	12.5	1.3
	Alkalinity (mg/L)	7	12.6	14.1	13.4	13.4	0.5
	Photic Zone (m)	7	4.99	9.07	7.59	7.44	1.42
	Secchi (m)	7	2.13	3.64	3.11	2.99	0.51
	Bottom Depth (m)	7	16.5	16.9	16.9	16.8	0.2
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.007	0.016	0.004	0.004	0.002
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.004	0.136	0.005	0.027	0.049
	Total Kjeldahl Nitrogen (mg/L)	7	< 0.158	0.574	0.238	0.270	0.163
	Total Nitrogen (mg/L)[J]	7	< 0.109	0.579	0.240	0.296	0.184
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.004	0.005	0.002	0.003	0.001
	Total Phosphorus (mg/L)[J]	7	0.006	0.016	0.010	0.011	0.004
	CBOD-5 (mg/L)	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.3	2.5	2.4	2.4	0.1
	Biological						
	Chlorophyll a (mg/m³)	7	1.07	17.80	2.14	5.66	6.25
	E. coli (MPN/DL)[J]	4	1	1	1	1	0
MARE-10	**Physical**						
	Turbidity (NTU)	7	1.4	3.3	1.8	2.0	0.7
	Total Dissolved Solids (mg/L)	7	11.0	42.0	25.0	25.6	9.2
	Total Suspended Solids (mg/L)	7	< 1.0	3.0	2.0	1.7	1.1
	Hardness (mg/L)	4	11.3	14.1	12.1	12.4	1.2
	Alkalinity (mg/L)	7	12.1	15.2	13.2	13.3	1.1
	Photic Zone (m)	7	4.84	9.68	8.00	7.56	1.82
	Secchi (m)	7	2.48	4.12	3.31	3.33	0.58
	Bottom Depth (m)	7	24.5	25.5	25.3	25.2	0.3
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.007	0.016	0.004	0.004	0.002
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	< 0.004	0.149	0.002	0.030	0.054
	Total Kjeldahl Nitrogen (mg/L)[J]	7	0.091	0.374	0.196	0.215	0.102
	Total Nitrogen (mg/L)[J]	7	< 0.093	0.523	0.234	0.245	0.145
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.004	0.004	0.002	0.003	0.001
	Total Phosphorus (mg/L)[J]	7	0.005	0.013	0.010	0.009	0.003
	CBOD-5 (mg/L)	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.3	2.5	2.4	2.4	0.1
	Biological						
	Chlorophyll a (mg/m³)	7	1.60	9.61	4.45	4.32	2.78
	E. coli (MPN/DL)[J]	4	1	3	2	2	0

Appendix Table 2. (continued)

Station	Parameter	N	Min	Max	Med	Mean	SD
MARE-11	**Physical**						
	Turbidity (NTU)	7	1.3	2.0	1.6	1.6	0.3
	Total Dissolved Solids (mg/L)	7	< 1.0	40.0	26.0	21.3	15.8
	Total Suspended Solids (mg/L)	7	< 1.0	2.0	1.0	1.3	0.7
	Hardness (mg/L)	4	11.2	14.0	12.0	12.3	1.2
	Alkalinity (mg/L)	7	12.3	13.9	12.6	12.9	0.6
	Photic Zone (m)	7	6.61	10.05	8.86	8.59	1.15
	Secchi (m)	7	2.78	4.59	3.50	3.65	0.62
	Bottom Depth (m)	7	30.0	34.0	30.6	31.4	1.7
	Chemical						
	Ammonia Nitrogen (mg/L)	7	< 0.007	0.016	0.004	0.004	0.002
	Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.004	0.134	0.002	0.028	0.048
	Total Kjeldahl Nitrogen (mg/L)[J]	7	< 0.077	0.388	0.144	0.148	0.129
	Total Nitrogen (mg/L)[J]	7	< 0.040	0.522	0.170	0.176	0.172
	Dis Reactive Phosphorus (mg/L)[J]	7	< 0.004	0.004	0.002	0.002	0.001
	Total Phosphorus (mg/L)[J]	7	0.005	0.011	0.008	0.008	0.002
	CBOD-5 (mg/L)	7	< 2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	2.3	2.4	2.4	2.4	0.0
	Biological						
	Chlorophyll a (mg/m³)	7	1.60	12.50	3.20	4.59	3.70
	E. coli (MPN/DL)[J]	4	1	2	1	1	1

J=one or more of the values provided are estimated; < = Actual value is less than the detection limit