DAN RIVER LONG–TERM ENVIRONMENTAL MONITORING REPORT

March 2019

Water Resources
DUKE ENERGY
Raleigh, North Carolina

Preface

This copy of the report is not a controlled document as detailed in the *Environmental Services Biology Program Quality Assurance Manual*. Any changes made to the original of this report subsequent to the date of issuance can be obtained from:

Water Resources
DUKE ENERGY
410 South Wilmington Street
Raleigh, North Carolina 27601

Table of Contents

Preface ii
List of Tables iv
List of Figures iv
List of Appendices vi
Metric-English Conversion and Units of Measure viii
Executive Summary xi
1 Dan River Long Term Environmental Monitoring Report 1
1.1 Background 1
1.2 Report Organization 1
1.3 Study Area Descriptions 1
1.4 Objectives and Methods 4
2 Results of Environmental Monitoring During 2015-2017 9
2.1 Limnology 9
2.1.1 Temperature and Dissolved Oxygen 9
2.1.2 Water Clarity 9
2.1.3 Nutrients 9
2.1.4 Ions, Hardness and Specific Conductance 10
2.1.5 Alkalinity and pH 10
2.2 Trace Elements in Water 11
2.3 Trace Elements in Biota and Sediments 12
2.3.1 Sediments 12
2.3.2 Periphyton, Benthic Macroinvertebrate and *Corbicula* 13
2.3.3 Fish 14
2.4 Benthic Macroinvertebrate Community 15
2.5 Fisheries 19
2.5.1 Methods 19
2.5.2 Fish Community Composition and Richness 20
2.5.3 Analysis of Fish Community Similarity and Diversity 22
2.5.4 Reproductive, Recruitment and Health of Representative Important Species 26
2.5.5 Index of biotic Integrity Metrics 30
2.5.6 Deformities, Anomalies and Disease 32
3 Summary and Conclusions 35
4 References 36

List of Tables

1-1 GPS coordinates, channel widths and habitat characteristics of transects used in the Dan River long-term monitoring post ash release, 2015-2017..... 5

1-2 Field sampling and laboratory methods utilized in the Dan River long-term environmental monitoring program..... 7

1-3 Statistical analyses performed on data collected for the Dan River long-term environmental monitoring program..... 8

2-1 NCDWR standard qualitative methods (NCDWR 2016)..... 15

2-2 Transect sampling date(s) and water quality data recorded on that date..... 17

2-3 Percent EPT by Transect location in the Dan River from 2015-2017..... 18

2-4 Percent Intolerant, Intermediate and Tolerant taxa by Transect location in the Dan River from 2015-2017..... 18

2-5 Shannon-Weiner Diversity Index (Natural Log) and Pielou's Evenness calculated for the fish assemblages by transect by year..... 26

2-6 IBI metrics for Dan River and Kerr Reservoir location for 2015..... 30

2-7 IBI metrics for Dan River and Kerr Reservoir location for 2016..... 31

2-8 IBI metrics for Dan River and Kerr Reservoir location for 2017..... 31

2-9 Deformities, anomalies and disease of fish collected from the Dan River and Kerr Reservoir by transect and year, 2015-2017..... 33

List of Figures

1-1 Dan River Sampling Locations..... 3

2-1 Dendrogram of fish assemblages at transects of the Dan River and Kerr Reservoir from 2015-2017 from Bray Curtis similarities (square root transformed species abundances)... 23

2-2 Non-metric multi-dimensional scaling plot of fish assemblages at sampling locations on the Dan River and Kerr Reservoir from 2015–2017 from Bray Curtis similarities (square root transformed species abundances)..... 24

2-3 Non-metric multi-dimensional scaling plot of Rohde et al. (2001) fish assemblage data and Duke Energy 2015-2017 fish assemblage data showing longitudinal successional changes from upstream to downstream……..... 25

2-4 Examples of fish with deformities, anomalies and disease..... 34

List of Appendices

A Spatial trends of means and ranges for selected limnological variables from near-bottom waters of Dan River during 2015 38

B Spatial trends of means and ranges for selected limnological variables from near-bottom waters of Dan River during 2016 40

C Spatial trends of means and ranges for selected limnological variables from near-bottom waters of Dan River during 2017 42

D Spatial trends of means and ranges for trace element variables from near-bottom waters of Dan River during 2015 44

E Means and ranges of trace element concentrations (µg/L) at sampling stations relative to aquatic life and human health screening values during 2015 46

F Number of exceedances by station of either aquatic life or human health screening values from water samples collected in 2015 47

G Spatial trends of means and ranges for trace element variables from near-bottom waters of Dan River during 2016 48

H Means and ranges of aqueous trace element concentrations (µg/L) at sampling stations relative to aquatic life and human health screening values during 2016 50

I Number of exceedances by station of either aquatic life or human health screening values from water samples collected in 2016 52

J Spatial trends of means and ranges for trace element variables from near-bottom waters of Dan River during 2017 54

K Means and ranges of aqueous trace element concentrations (µg/L) at sampling stations relative to aquatic life and human health screening values during 2017 56

L Number of exceedances by station of either aquatic life or human health screening values from water samples collected in 2017 57

M Trace element mean and range concentrations in µg/g wet weight from sediments across sampling sites that some or all of the values exceeded ecological screening values during 2015 58

N Trace elements observed above screening values and exceedances by element for sediment samples collected in 2015 59

O Trace element mean and range concentrations in µg/g wet weight from sediments across sampling sites that some or all of the values exceeded ecological screening values during 2016 60

P Trace elements observed above screening values by element for sediment samples collected in 2016 61

Q Trace element mean and range concentrations in µg/g wet weight from sediments across sampling sites that some or all of the values exceeded ecological screening values during 2017 62

R Trace elements observed above screening values by element for sediment samples collected in 2017 63

S	Spatial trends of means and ranges for trace element variables from periphyton in the Dan River during 2015	64
T	Spatial trends of means and ranges for trace element variables from periphyton in the Dan River during 2016	66
U	Spatial trends of means and ranges for trace element variables from periphyton in the Dan River during 2017	68
V	Spatial trends of means and ranges for trace element variables from benthic macroinvertebrates in the Dan River during 2015	70
W	Spatial trends of means and ranges for trace element variables from benthic macroinvertebrates in the Dan River during 2016	72
X	Spatial trends of means and ranges for trace element variables from benthic macroinvertebrates in the Dan River during 2017	74
Y	Spatial trends of means and ranges for trace element variables from *Corbicula fluminea* in the Dan River during 2015	76
Z	Spatial trends of means and ranges for trace element variables from *Corbicula fluminea* in the Dan River during 2016	78
AA	Spatial trends of means and ranges for trace element variables from *Corbicula fluminea* in the Dan River during 2017	80
BB	Trace element concentrations in µg/g wet weight from fish samples across sampling sites during 2015	82
CC	Trace elements observed above screening values by element for fish samples by species collected in 2015	83
DD	Trace element concentrations in µg/g wet weight from fish samples across sampling sites during 2016	84
EE	Trace elements observed above screening values by element for fish samples by species collected in 2016	85
FF	Trace element concentrations in µg/g wet weight from fish samples across sampling sites during 2017	86
GG	Trace elements observed above screening values by element for fish samples by species collected in 2017	87
HH	Benthic macroinvertebrate descriptor in the Dan River at transects through years 2015-2017	88
II	Fish taxa collected from the Dan River and Kerr Reservoir by all geartypes during 2015	91
JJ	Fish taxa collected from the Dan River and Kerr Reservoir by all geartypes during 2016	93
KK	Fish taxa collected from the Dan River and Kerr Reservoir by all geartypes during 2017	95
LL	Bull Chub length frequency histograms from Transects A, B, D, E and F, 2015-2017	97
MM	White Shiner length frequency histograms from Transects A, B, D, E, F and G, 2015-2017	102

NN Golden Redhorse length frequency histograms from Transects A, B, D, E, F and G, 2015-2017 108

OO Redbreast Sunfish length frequency histograms from Transects A, B, D, E, F and G, 2015-2017 113

PP Smallmouth Bass length frequency histograms from Transects A, B, D, E and F, 2015-2017 119

QQ Gizzard Shad length frequency histograms from Transect I during 2015, 2016, and 2017 124

RR Bluegill length frequency histograms from Transect I during 2015, 2016, and 2017 125

SS Notchlip Redhorse length frequency histograms from Transect I during 2015, 2016, and 2017 126

TT Largemouth Bass length frequency histograms from Transect I during 2015, 2016, and 2017 127

UU Relative weight (W_r) values across sampling sites for Bull Chub during 2015, 2016, and 2017 128

VV Relative weight (W_r) values across sampling sites for Golden Redhorse during 2015, 2016 and 2017 129

WW Relative weight (W_r) values across sampling sites for Redbreast Sunfish during 2015, 2016 and 2017 130

XX Relative weight (W_r) values across sampling sites for Smallmouth Bass during 2015, 2016 and 2017 131

YY Relative weight (W_r) values at Transect I for Gizzard Shad, Notchlip Redhorse, Bluegill and Largemouth Bass during 2015, 2016 and 2017 132

Metric-English Conversion and Units of Measure

Length

1 micron (µm) = 4.0 x 10^{-5} inch
1 millimeter (mm) = 1000 µm = 0.04 inch
1 centimeter (cm) = 10 mm = 0.4 inch
1 meter (m) = 100 cm = 3.28 feet
1 kilometer (km) = 1000 m = 0.62 mile

Area

1 square meter (m^2) = 10.76 square feet
1 hectare (ha) = 10,000 m^2 = 2.47 acres

Volume

1 milliliter (ml) = 0.034 fluid ounce
1 liter = 1000 ml = 0.26 gallon
1 cubic meter = 35.3 cubic feet

Weight

1 microgram (µg) = 10^{-3} mg or
10^{-6} g = 3.5 x 10^{-8} ounce
1 milligram (mg) = 3.5 x 10^{-5} ounce
1 gram (g) = 1000 mg = 0.035 ounce
1 kilogram (kg) = 1000 g = 2.2 pounds
1 metric ton = 1000 kg = 1.1 tons
1 kg/hectare = 0.89 pound/acre

Temperature

Degrees Celsius (°C) = 5/9 (°F-32)

Specific Conductance

µS/cm^2 = Microsiemens/centimeter squared

Turbidity

NTU = Nephelometric Turbidity Unit

Executive Summary

After three years of intensive monitoring of the Dan River and Kerr Reservoir from 2015 through 2017 following the 2014 release of approximately 39,000 tons of coal ash from the retired Dan River Steam Station, Duke Energy found no long-term impacts to the aquatic environment related to that event. The monitoring program generated very large datasets of many different types consisting of water quality, water chemistry including trace element contaminants, trace element contaminants in sediments, periphyton, benthic macroinvertebrates, *Corbicula* spp. (as surrogate for native mussels), and fish, as well as aquatic community data for benthic macroinvertebrates and fish. Through analysis of these data we showed the aquatic environment and community remained healthy and diverse in the study area over the three years and no contaminants in the environment were linked to the coal ash release. Exceedances of ecological screening values by a small number of trace elements in water, sediments, and fish were seen during the study throughout study area both upstream and downstream of the ash release. These trace elements when present are not considered indicative of the presence of coal ash attributable to the 2014 event.

1 Dan River Long-Term Environmental Monitoring Report

1.1 Background

As a result of a pipe failure and subsequent ash release from the retired Dan River Steam Station (DRSS) ash pond into the Dan River on February 2, 2014, Duke Energy committed to conducting intensive monitoring of the river and the headwaters of Kerr Lake for three years (2015–2017) to assess potential environmental impacts as well as to support the Natural Resource Damage Assessment and Restoration (NRDAR) process. A sampling and analysis study plan was submitted to the NRDAR Trustees including the United States Fish and Wildlife Service, the North Carolina Department of Environmental Quality (NCDEQ), and the Virginia Department of Environmental Quality (VADEQ) in February of 2015. This report contains the results, analysis, discussion, and summary and conclusions of the three-year monitoring effort.

1.2 Report Organization

This report is organized into a written part and a digital part contained on a Compact Disc (CD) due to the large volume of data and information generated during three years of intensive sampling on the Dan River and Kerr Reservoir. For the written part, only pertinent information concerning the overall environmental status of the system and the interaction of coal ash with the aquatic environment and the aquatic community is presented herein. Other data and related information considered beyond the scope of this report are captured electronically on the enclosed CD located in a plastic holder affixed to the inside back cover of hard copies of the report. These electronic files include the full datasets of water quality and water chemistry, the full datasets of trace elements in biota and sediments, laboratory Electronic Data Deliverables, the laboratory level 4 quality assurance and quality control output, various statistical output information (e.g. SigmaPlot® statistical output), ion charge-balance calculations for all water sampling trips by location and year, and the complete third-party mussel survey report.

1.3 Study Area Description

The upstream extent of the study area begins in the Inner Piedmont physiographic province of the Dan River at GPS coordinates 36.366043ºN -80.127539ºW and continues downstream to the headwaters of the John H. Kerr Reservoir at GPS coordinates 36.676106ºN -78.629956ºW, representing approximately 201 river-kilometers (125 river-miles) (Figure 1-1). The river traverses Stokes, Rockingham, and Caswell counties of North Carolina and Pittsylvania and Halifax counties of Virginia within the study area. The major tributaries include the Smith River, the Bannister River, and the Staunton River. The land uses along the river includes agricultural, forested, industrial, and residential. In North Carolina, NCDEQ classifies the Dan River as C (Aquatic Life, Secondary Recreation, Freshwaters) and Tr (Trout Waters). In Virginia, all waters, including the Dan River and Kerr Reservoir, are designated by the VADEQ according to the following uses: “recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish”.

Sampling locations were established as river reaches of a specified distance (usually 1500 m) depending on the size of the river (i.e., maximum water width) and other physical features such as barriers (shoals, dams, etc.), habitat, and access. Descriptions of all sampling transects are provided (Table 1-1). Three locations including Transects A, B, and C were selected as upstream reference sites based on ease of access, use as historical Duke Energy sampling locations, and habitat type for comparison to the locations downstream of the DRSS and the ash release point on the river. Transect A was located in the Inner Piedmont Physiographic Province and is dominated by wadeable shoals, riffle and shallow sand/cobble habitat. However, numerous small pools exist here as well. Transects B through E were in the Fault Basin province. These transects were dominated by river runs but Transects D and E also have non-wadeable (at typical river flow) shoals interspersed. Transect D included the reach from the site of the ash release and downstream approximately 1500 meters (m). Transect E is located a little further downstream and is also approximately 1500 meters long terminating just below Drapers Landing at the NC 700 highway bridge. Transects F through I were located in the Piedmont Lowlands physiographic province. Transect F began at Wares Shoal separating the Fault Basin from the Piedmont Lowlands provinces. The transect area continued downstream as a long run with occasional pools and sand/cobble bars. Transects A through F and Transect I were each approximately 1500 m in length. Transect G was lengthened to approximately 3000 m to allow inclusion of distinctly different habitats during fisheries sampling. This transect was a deep water reach due to Schoolfield Dam located near the downstream end. Though not very large, this area is locally referred to as a “reservoir” because the water impounded by the dam deepens and widens and the flow slows. Transect H is a shallow wadeable sand/silt location (at moderate river flow) found at the downstream extreme of the Dan River before the confluence with the Staunton River and the beginning of the Kerr Reservoir headwaters. The site was selected as a good location for sampling benthic macroinvertebrates. Transect I was selected because the headwaters of Kerr Reservoir would most likely show effects, if any, because of the rapid settling potential of suspended ash particles.

Within the transects, stations were established for specific locations where samples for water quality, water chemistry, benthic macroinvertebrate samples, sediment samples, periphyton samples, and *Corbicula* were collected. For fish collection, the transects were also divided into stations along either side of the river and further broken up into segments (replicates). The naming scheme consisted of a combination of the transect letter designation and numeric station and replicate designations. For example, the water quality location for Transect A was Station A3 and an example of a fisheries sampling location at Transect D was Station D1-1.

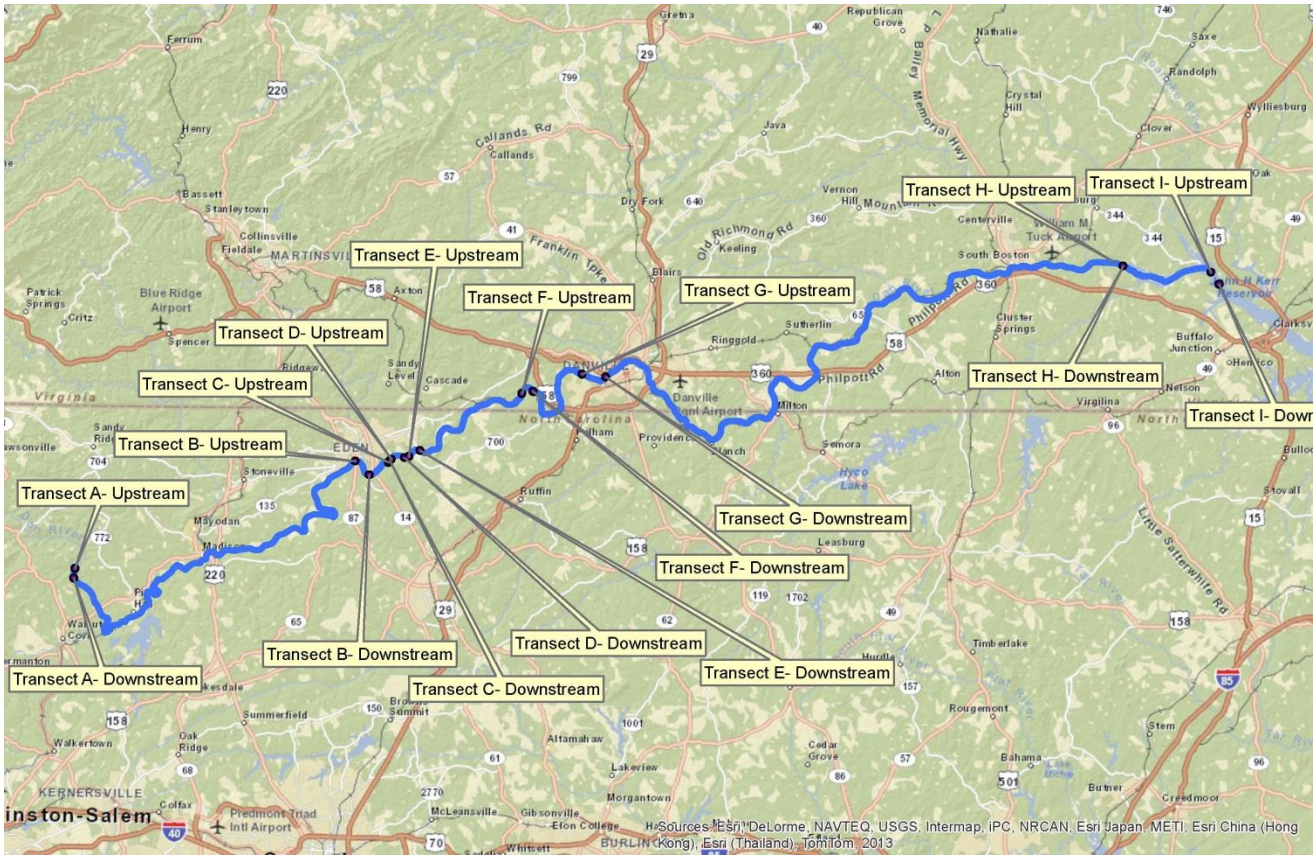


Figure 1-1. Dan River sampling locations.

1.4 Objectives and Methods

The objective of the Dan River 2015–2017 environmental monitoring program was to provide an assessment of the potential effects of the 2014 coal ash release on the Dan River's water and aquatic organisms. Secondary objectives of the program were to document non-coal ash related environmental factors impacting the aquatic community such as sedimentation and contaminants from elsewhere in the river. These objectives were consistent with the Dan River Long-Term Plan (LTMP) submitted to the NRDAR trustees.

Limnology (water quality and water chemistry) and trace elements in biota and sediments were assessed in the Dan River and Kerr Reservoir (Figure 1-1, Table 1-1). The water chemistry and trace elements analyses of biota and sediment were conducted by Pace Analytical laboratories, which is certified by NCDEQ and VADEQ using U. S. Environmental Protection Agency (USEPA) approved methods (Table 1-2). The accuracy and precision of laboratory analyses of water chemistry and trace element data were determined with analytical standards, sample replicates, and reference materials. For calculation of means in this report, concentrations less than the reporting limit were assumed to be at one-half the reporting limit. Data were analyzed using appropriate statistical methods (Table 1-3).

Table 1-1. GPS coordinates, channel widths and habitat characteristics of transects used in the Dan River long-term monitoring post ash release, 2015-2017.

Transect	Coordinates decimal degrees for Upstream (Downstream)	Approx. River Kilometer (Mile) [1]	Approx. Max. Channel Width (m)	Physiographic province subdivision[2]/ Habitat Description
Mainstem				
A Access ramp near Hemlock Golf Club, Walnut Cove, NC	Lat. 36.366043 Long. -80.127539 (Lat.36.365198 Long. -80.128397)	209 (130)	45	Inner Piedmont Physiographic Province. Simple shoal with bedrock outcrops and boulders, cobble intermixed with gravel and sand, and cobble and gravel bars present with some sand and silt deposition. Slower Pools occur downstream of shoals. Woody debris and some rooted aquatic vegetation.
B Leaksville access ramp, Leaksville, NC	Lat. 36.486000 Long. -79.761440 (Lat. 36.471399 Long. -79.743094)	150 (93)	60	Fault Basin Physiographic Province. Deeper location due to low head dam located approximately 2.7 kilometers downstream of the lower crossing transect line.
C Below low head dam near DRSS, upstream of ash release	Lat. 36.48500 Long. -79.719780 (Lat. 36.486530 Long. -79.715900)	145 (90)	90	Fault Basin Physiographic Province. Shoals below tail race of low head dam located at the retired DRSS site.
D Site of ash release	Lat. 36.488240 Long. -79.713928 (Lat. 36.489789 Long. -79.696543)	143 (89)	45	Fault Basin Physiographic Province. Large Shoals and runs with extensive sand and silt deposition. Areas of small boulder and cobble substrate are disbursed throughout the transect particularly along east side of channel. Woody debris is prevalent and little aquatic vegetation present. Portion of area on north bank is industrial and stabilized by rip rap. South side is destabilized by cattle along long portions of the bank. The Town Creek tributary confluence is located on south side approximately two thirds of the way of sample location.
E Area terminating downstream of Draper's Landing at Highway 700 Bridge	Lat.36. 491311 Long. -79.691482 (Lat. 36.497534 Long. -79.676712)	142 (88)	75	Fault Basin Physiographic Province. Shoals and runs intermixed with extensive sand and silt deposition. Areas of small boulder and cobble substrate are disbursed throughout the transect particularly along east side of channel. Woody debris is prevalent and little aquatic vegetation present.

Table 1-1. (cont.)

Transect	Coordinates decimal degrees for Upstream (Downstream)	Approx. River Kilometer (Mile)[1]	Approx. Max. Channel Width (m)	Physiographic province subdivision[2]/ Habitat Description
Mainstem				
F Wares Shoal upstream divides the Fault Basin and Piedmont Lowlands	Lat.36. 491311 Long. -79.691482 (Lat. 36.497534 Long. -79.676712)	124 (77)	90	Piedmont Lowlands Physiographic Province. Wares Shoal at upper end with long run downstream. *Podostemum* sp. and *Potamogeton crispus* aquatic vegetation prevalent in shoal. Sand and silt deposition found throughout the sample location with woody debris along the banks on each side of the river.
G Pooled area upstream of Schoolfield Dam in Danville, VA	Lat. 36.579419 Long. -79.464528 (Lat. (36.579419 Long. -79.464528)	111 (69)	150	Piedmont Lowlands Physiographic Province. Relatively deep and wide, slow moving water due to the 26-m tall Schoolfield Dam at downstream end of transect. Bottom is heavily silted with a mix of gravel and sand.
H Downstream of Banister River and upstream of braded reach at the beginning near headwaters of Kerr Reservoir	Lat. 36.698288 Long. -78.765010 (Lat. 36.69439 Long. -78.754965)	22 (14)	120	Piedmont Lowlands Physiographic Province. Shallow, cobble intermixed with gravel and sand, gravel bars present with some sand and silt deposition. Woody debris and some rooted aquatic vegetation present.
I Headwaters of Kerr Reservoir	Lat. 36.688519 Long. -78.639816 (Lat. 36.676106 Long. -78.629956)	NA	1,200	Piedmont Lowlands Physiographic Province. Upper section of Kerr Reservoir below Staunton State Park with approximately 3-4 meters of water depth.

[1]River kilometer was calculated from river miles following Trout, 2003. River kilometer 0 occurs at the confluent of the Dan River and the Staunton River.

[2]Physiographic provinces subdivision follows Physiographic provinces subdivision follows the naming convention used by Rohde et al. (2001, 2003)

Table 1-2. Field sampling and laboratory methods utilized in the Dan River long-term environmental monitoring program.

Program	Method
Water quality	Temperature, dissolved oxygen, pH, specific conductance, and turbidity were measured with a YSI® using a multi-parameter meter with a submersible sonde. Measurements were taken from near-bottom except at Transect I where they were measure at 1-m intervals from the surface to near bottom
Water chemistry	Samples were pumped with a Cole Palmer Masterflex® portable sampler directly into appropriate containers or through a 0.45µm filter prior to being introduced into the containers, transported to the laboratory on ice, and analyzed according to applicable analytical methodologies.
Trace elements	Water, sediments, and muscle tissue of selected fish were analyzed by standard analytical techniques laboratory for selected trace metals and metalloids. Water samples were shipped to Pace Analytical for analysis by USEPA Methods 200.7, 200.8, 245.1, 300.0, 350.1, 351.2, 353.2, 365.1, 1631E, and Standard Methods 2320B, 2540C, 4500-Cl-E, and 5310B. The biota and sediment samples were homogenized, freeze-dried, and analyzed by Pace Analytical using USEPA Methods 6020 or Method 7473 (mercury only). Quality assurance and quality control was achieved by analytical standards, replicates, and certified reference materials. The trace elements analyzed in all media were listed in the original study plan and are also listed herein in the appendices of this report.
Benthic macroinvertebrates	Field sampling based on the Duke Energy Benthic Invertebrate Rapid Bioassessment Sampling procedure. Samples collected in the field, preserved in 95% ethanol, and returned to the laboratory for processing and identification.
Fisheries	Up to six electrofishing samples (replicates) of two to three hundred meters each were collected four times per year at each transect station using a Smith-Root Type 7.5 gpp equipped, Wisconsin-design electrofishing boat with pulsed DC current. Fish were identified, measured to the nearest mm, weighed to the nearest gram, examined for the presence of parasites, disease, and anomalies/deformities, and released. Some fish were retained for trace element analyses. Other geartypes used once per calendar year (summer months) depending on location included pram electrofisher, fyke nets, d-hoop nets, back pack electrofisher with 10’ flat seine (shoals and riffles only), and 20’ flat seine.

Table 1-3. Statistical analyses performed on data collected for the Dan River long-term environmental monitoring program. [1]

Program	Variable	Analysis	Main effect(s)
Water quality	Water temperature, dissolved oxygen, specific conductance	One-way ANOVA (block on month) or either Kruskal-Wallis non-parametric ANOVA on ranks or Equal Variance Test (Brown-Forsythe); $\alpha = 0.05$	Station
Water chemistry	Selected chemical variables (those meeting minimum criteria for analyses)	One-way ANOVA (block on month) or either Kruskal-Wallis non-parametric ANOVA on ranks or Equal Variance Test (Brown-Forsythe); $\alpha = 0.05$	Station
Trace elements	Selected trace element variables (those meeting minimum criteria for analyses)	One-way ANOVA (block on month) or either Kruskal-Wallis non-parametric ANOVA on ranks or Equal Variance Test (Brown-Forsythe); $\alpha = 0.05$	Transect
Benthic macroinvertebrates	Total number by taxa	ANOSIM, Dendrogram/non-metric Multi-dimensional scaling, Shannon-Wiener diversity index	Transect
Fisheries	Total number by taxa	Bray-Curtis similarity, Dendrogram/non-Metric Multi-Dimensional Scaling, Shannon-Wiener diversity index and Pielou's Evenness (H´, J´)	Transect

[1]Type I error rate of 5% ($\alpha = 0.05$) was used to judge the significance of water quality/water chemistry statistical tests. A Type I error rate of 10% ($\alpha = 0.1$) was used to judge the significance of testing biological data. Various test methods were applied to determine where differences in means occurred for significant models including Fisher LSD, Dunn's, Tukey, Holm-Sidak.

2 RESULTS OF ENVIRONMENTAL MONITORING DURING 2015-2017

2.1 Limnology

2.1.1 Temperature and Dissolved Oxygen

Dan River generally exhibited typical annual thermal patterns each year from 2015 through 2017 with expected low water temperatures during the winter months and reasonably mild summer water temperatures (Appendices A, B, C). The general pattern each of these years was that of gradually increasing annual mean near-bottom water temperatures from upstream to downstream, as expected. There were no statistical differences in annual mean water temperatures among all sampling stations during both 2015 and 2017 when tested. But during 2016, there were statistical differences in the annual means that reflected the upstream to downstream increasing water temperature pattern with the greatest annual mean water temperature occurring at Station I in Kerr Reservoir. During 2015, near-bottom water temperatures among the transects ranged from 3.9°C occurring at Station E1 during winter to 26.9°C recorded at Station I3 in Kerr Reservoir during summer months. Similar water temperature patterns within the study area were observed in 2016 and 2017. Overall, water temperatures were within expected ranges during all annual seasons and the measured temperatures during the warmest months were relatively mild.

All near-bottom water mean DO concentrations were above the 5 mg/L standards set by NCDEQ and VADEQ throughout Dan River during 2015-2017 (Appendices A, B, C). Only Kerr Reservoir (Station I3) in Virginia had DO concentrations fall below 5 mg/L on four out of the 77 measurements collected at this location (on average approximately 3 m in depth depending on reservoir level). No statistical differences in dissolved oxygen concentrations were found among any of the sampling locations when analyzed within year by pairwise testing (usually Kruscal-Wallace non-parametric one-way ANOVA).

2.1.2 Water Clarity

Mean turbidity values were also statistically similar among all stations during each year from 2015 through 2017 (Appendices A, B, C). However, the turbidity measurements in the river were much greater during the month of May 2016, than those observed other months due to a very high river flow (approximately 13,000 cfs at the USGS Gage near Wentworth, NC, RKM 166, on 5/3/2016). This high flow event affected the overall statistical testing of turbidity in 2016.

2.1.3 Nutrients

During 2015, no statistical differences were observed in the annual means for total ammonia, total nitrate+nitrite nitrogen, total nitrogen, and total kjeldahl nitrogen (i.e., total of organic nitrogen and ammonia) concentrations. There were significant differences ($p < 0.05$) in total phosphorous concentrations observed when compared within year among the stations (Appendix A) but these were considered to be relatively minor. All annual mean nutrient concentrations among sampling stations did not differ during 2016 including total ammonia, total nitrate+nitrite nitrogen, total kjeldahl nitrogen, total nitrogen, and total phosphorous concentrations (Appendix B). However, it must be noted that in May of 2016, an extremely high river flow event occurred affecting phosphorus

and some other parameters. An individual total phosphorus concentration of 1.102 mg/L (considered a valid measurement) was measured at Station B1, a reference location near Eden, North Carolina. As a result, the overall annual mean at Station B1 was calculated to be much greater than other locations. The reason this location was more affected in terms of water chemistry sample results than others is not clear. In 2017, all nutrients except nitrate+nitrite nitrogen did not differ among the stations (Appendix C). The nitrate + nitrite nitrogen concentrations among stations varied within approximately a 0.2 mg/L of each other and was not considered environmentally important. The nutrients, considered individually, had similar overlapping ranges each year from 2015 through 2017.

The annual mean total organic carbon concentrations (TOC) during 2015 were statistically similar at all stations with concentrations ranging from 2.3 mg/L to 3.9 mg/L (Appendix A). Similarly, there were no statistical differences in the annual mean TOC concentrations among stations during 2016 with mean values ranging from 2.4 mg/L to 4.0 mg/L (Appendix B). During 2017, statistical analysis determined significant differences in the annual mean TOC concentrations, however, these mean values (1.4 mg/L to 4.1 mg/L) were still within the ranges of individual values observed from 2015 and 2016. Overall, the minor differences were not considered environmentally important and the overall TOC concentrations during the study were deemed to be moderate and stable.

2.1.4 Ions, Total Dissolved Solids, Hardness and Specific Conductance

The 2015 annual mean concentrations of most of the major ions, total dissolved solids concentrations and hardness concentrations differed among sampling stations ($p < 0.05$; Appendix A). Generally, these constituents increased from upstream to downstream. In most cases, Station A1 had the lowest concentrations while the stations from B through H, varied in terms of concentrations possibly due to the variability of dischargers along the river. In some cases, these constituents exhibited the greatest concentrations in Kerr Reservoir. This tendency of increasing mean concentration pattern from upstream to downstream is not unusual in river systems since ionic inputs occur from runoff and dischargers throughout the watershed and accumulate downstream. During 2016 and 2017, again, significant differences ($p < 0.05$) in many of the annual mean concentrations of the ions were noted among the sampling stations. The same longitudinal pattern was documented with the lowest annual mean concentrations observed at Station A1, more intermediate mean concentrations observed at Stations B1 through H2, and the highest concentrations observed at Station I3 (Appendices B, C). This pattern repeated each year with total dissolved solids (TDS) and hardness. Specific conductance was not significantly different ($p < 0.05$) among the stations during 2015 and 2016. However, the 2017 values did vary significantly with a similar pattern, as discussed above concerning TDS and hardness, of a lower annual mean value at station A1, and gradually increasing specific conductance downstream culminating with the greatest mean value in Kerr Reservoir at Station I3.

2.1.5 Alkalinity and pH

The annual mean total alkalinity concentrations varied significantly during 2015 and 2016 and like TDS and hardness, increased from upstream to downstream (Appendices A and B). The annual mean alkalinity concentrations during 2017 were not significantly different among stations (Appendix C). These alkalinity concentrations ranged from 9.0 to 50 mg/L representing a low to moderate buffering capacity in the Dan River and Kerr Reservoir.

The median pH values of the Dan River and Kerr Reservoir from 2015 to 2017 were generally slightly above neutral with circumneutral ranges within typically one pH unit of neutral throughout the system (Appendices A, B, C). The near-bottom water pH values ranged from 6.5 to 7.9 among all stations during 2015, from 6.4 to 7.8 during 2016, and from 6.6 to 8.1 during 2017.

2.2 Trace Elements in Water

During 2015–2017, 20 different trace elements (from the original study plan) were sampled six times per year and analyzed from all nine transects on the Dan River and Kerr Reservoir (Appendices D, G, J). Of the 20 trace elements measured during the study, four of them did not produce any annual means above the laboratory reporting limit (LRL) including antimony, mercury analyzed by USEPA Method 245.1 (Stations A1, C3, D3, E1, F3, H2, and I3), selenium, and silver. Thallium only showed a single annual mean concentration above the LRL during the three-year study. Arsenic, beryllium, and cadmium had annual means greater than the LRL but only in 2016. This annual mean increase is believed to be from the runoff during the extremely high river flows that occurred in May 2016. These concentrations would not have occurred under normal conditions. It is worth noting that the two sentinel trace elements arsenic and selenium, typically associated with the presence of coal ash, were either below not above the LRLs or only slightly above in 2016 despite the extreme rainfalls and river flows. In the case of arsenic, one of the two annual means slightly above the LRL was at Station B1, an upstream reference location. The other was located at the downstream location Station E1, just a little below the ash release point. In either case, due to the high river flow conditions in May 2016, these two observations are considered unrelated to coal ash.

The remaining 12 trace elements (aluminum, barium, boron, chromium, cobalt, copper, iron, lead, manganese, nickel, vanadium, and zinc) plus mercury (USEPA Method 1631E at Stations B1 and G1) analyzed from the Dan River and Kerr reservoir generated annual means greater than their respective LRLs each year from 2015 through 2017 (Appendices D, G, J). These trace elements were variable with respect to their concentration patterns relative to location in the system. The annual means of aluminum, boron, chromium, cobalt, iron, and lead concentrations each year from 2015 through 2017 all appeared to be unrelated to location. Whereas, depending on the year, the annual mean concentrations for barium, copper, and manganese showed a slightly increasing concentration pattern from upstream to downstream in the system.

Regardless of the resulting concentration patterns of trace elements during the three-year study, there were a limited number of trace element constituents that exceeded the aqueous screening values originally listed in the Dan River LTMP (Duke Energy 2015). During 2015, only three aqueous trace elements, including aluminum, iron, and mercury had values that exceeded their respective screening values for either aquatic or human health (Appendices D, E, F). Most aluminum concentrations measured during 2015 exceeded aquatic life screening value of 87 µg/L, therefore, the annual mean concentration also exceeded this screening value. However, none of the measurements exceeded the human health screening value of 8,000 µg/L. The exceedances observed included both the upstream reference sites and the sites downstream of the ash release indicating they were unrelated to the coal ash release. For iron, at the time the Dan River LTMP was written, the aquatic life water quality criteria/standard was 1000 µg/L in both North Carolina and Virginia, however, early in study both states eliminated iron from their respective listings as unnecessary and potentially over-protective. Regardless, there was no pattern of iron concentrations in water attributable to coal ash during the study. Low level mercury

(USEPA Method 1631E), according to the study plan, was only to be measured at Station B1 (reference site) and Station G1 to indicate possible coal ash related contamination. During 2015, only one of the 12 measurements at both these locations resulted in a value (0.0126 µg/L) above the aquatic life screening value concentration of 0.012 µg/L. This reading was measured at the upstream reference location Station B1. No exceedances of the aquatic life screening value for mercury were observed downstream of the ash release during 2015. Two observations of 0.12 µg/L thallium, one each at Station D3 and Station H2, were above the LRL (0.1 µg/L). However, these measurements were below the ecological screening value for thallium of 0.47 µg/L.

When comparing 2016 aqueous trace element concentrations against the water screening values, there was a noticeable increase in exceedances of the aqueous screening values (10 different elements exceeded) across the system, both upstream and downstream of the DRSS (Appendices G, H, I). Most of the 2016 aluminum measurements (48) exceeded screening values, like that observed in 2015. However, cobalt and copper had five and six exceedances, respectively, during 2016 both above and below the DRSS, whereas none were observed in 2015. Of the 54 measurements per analyte for lead and zinc during 2016, only a single measurement for lead at (Station E1) and two for zinc (at Stations B1 and E1) exceeded their respective screening values. As mentioned above, many water constituents were mobilized during May of 2016 with an extreme rain and high river flow event, and several trace element concentration increases were noted that month as well. It is Duke Energy's opinion that the 2016 increases of the annual means and number of exceedances of screening values by 10 different aqueous trace element constituents, again both upstream and downstream of DRSS, was a direct result of the flushing and runoff caused by the heavy rain and river flows in May.

Again in 2017, the annual mean aluminum and iron concentrations were consistently elevated at every sampling location in the Dan River and Kerr Reservoir relative to screening values (Appendices J, K, L). No other aqueous trace element annual mean concentrations exceeded any screening values during 2017. Only cobalt and copper had individual measurements that exceeded their respective screening values in water, both occurring at Station H2 in January 2017.

2.3 Trace Elements in Sediments and Biota

2.3.1 Sediments

Sediments were analyzed for 15 constituents that had associated ecological screening values originally listed in the Dan River LTMP and only those that exceeded these values will be presented herein. The complete results of trace elements in sediments can be found on the enclosed CD. Trace element concentrations in sediments were generally low relative to these ecological sediment screening values throughout the Dan River during 2015 (Appendix M). Of the 15 constituents with ecological screening values, only aluminum, barium, and manganese exceeded these values (Appendix N). Both aluminum and manganese are recognized as ubiquitous in the environment primarily a natural component of soil while barium can come from natural processes but can be associated with coal ash as well. The exceedances of the screening values for aluminum (3,200 µg/g wet weight) and barium (60 µg/g wet weight) occurred at all locations (both reference and downstream transects). Additionally, all individual sediment samples exceeded the screening values for these two elements except two samples for barium. However, due to the distribution of these trace elements among the samples, they were not considered to be related to the coal ash release. Manganese, was below the ecological

sediment screening value (460 µg/g wet weight) at all locations during 2015 except Transect H where two of the three replicates here exceeded the value. Again, this naturally occurring element was not considered related to the DRSS coal ash release in 2014.

During 2016, trace elements concentrations in sediments observed above the ecological screening values for sediments were aluminum, barium, manganese, and selenium (Appendix O). Aluminum was above (all measurements) the screening values at all the transects, as in 2015 (Appendix P). Barium showed measurements above the screening values at each location except Transect E, just downstream of the 2014 coal ash release. Exceedances of the selenium ecological screening value (2.0 µg/g wet weight) were observed in the sediments in 2016 at a reference location Transect C (one measurement of 2.06 µg/g wet weight) and downstream at Transect F (two measurements of 2.56 and 2.57 µg/g wet weight). As these occurrences were each an isolated exceedance upstream at a reference location and one at a downstream location during 2016, there does not appear to be a relationship between the selenium observed in these two instances and the ash release.

Aluminum, barium, and manganese were again the only trace elements in sediments observed to exceed the sediment ecological screening values during 2017 (Appendix Q). All locations sampled showed that aluminum measurements were above the screening values, consistent with the 2015 and 2016 measurements (Appendix R). There were measurements of barium above sediment ecological screening values for all transects, however, not in all cases. Lastly, a single exceedance of the manganese sediment screening value at the reference location Transect B was observed during 2017.

The primary indicator elements of coal ash presence, arsenic and selenium, in Dan River and Kerr Reservoir sediments from 2015 through 2017 were suggestive of no major presence of ash. There were no arsenic concentrations measured above the 9.8 µg/g (wet weight) ecological screening value during the entire study period. And as stated above, only three isolated selenium measurements were slightly above the selenium ecological screening value and one of those occurred at the upstream reference location Transect C and upstream of coal ash spill.

2.3.2 Periphyton, Benthic Macroinvertebrates and *Corbicula*

For non-fish biota such as periphyton and benthic macroinvertebrates, there are no ecological screening values for trace elements specific to the two respective states, North Carolina and Virginia, for comparison purposes. Therefore, the trace element results for non-fish biota are presented herein for informational purposes only. During the three study years, in almost all cases there was the presence of some observable concentration (i.e., above LRLs) for all trace elements analyzed in non-fish biota at every sampling location in the Dan River (Appendices S, T, U, V, W, X, Y, Z, AA). The two sentinel trace elements, arsenic and selenium, considered indicative of potential coal ash presence in the environment, were very low (generally < 1 µg/g wet weight; an arbitrary benchmark concentration) in non-fish biota during the entire study period. Only one measurement each for arsenic and selenium from the same periphyton sample at Transect F in 2016 was greater than 1 µg/g wet weight (Appendix T). This result, coupled with the observation of an exceedance of the selenium screening value in sediments at Transect C (reference site) and Transect F suggests that these observations were related and were likely due to the high flow and sediment moving events in 2016. It is worth noting that one of the original concerns when developing Dan River LTMP was that periphyton may provide a pathway for arsenic into the food web. The data suggests that substantial exposure of periphyton to

arsenic did not occur during the study. Also, recent research determined that while periphyton can bioaccumulate arsenic to a substantial degree when exposed, trophic transfer to higher food web levels such as benthic macroinvertebrates was not shown to occur (Lopez et al. 2016).

Notable measurements in non-fish biota that were greater than 1 µg/g wet weight were observed each year during the three-year study for other trace elements, including aluminum, barium, chromium, cobalt, copper, iron, manganese, nickel, vanadium, and zinc. Again, since there are no ecological screening values for these biota, the significance of the observations above 1 µg/g wet weight is not put forth. Nevertheless, based on the variability among the transects and patterns of accumulation in non-fish biota both upstream and downstream of the ash release point, we do not consider these observations directly linked to the presence of coal ash released from DRSS.

2.3.3 Fish

During the Dan River LTMP, the annual mean fish tissue trace element concentrations for only cobalt (in 2015 and 2016), copper (in 2015), mercury (in 2017), and thallium (in 2015–2017) exceeded the applicable ecological screening values (Appendices BB, CC, DD, EE, FF, GG). All other annual means and individual trace element concentrations in fish were below applicable screening values. For cobalt, North Carolina has designated a screening value of 0.12 µg/g wet weight in fish tissue, which is only applicable to Transects A, B, D, and E on the Dan River.

During 2015, where collected, cobalt concentrations in the tissue of Golden Redhorse *Moxostoma erythrurum*, Largemouth Bass *Micropterus Salmoides*, Smallmouth Bass *Micropterus Dolomieu*, and Redbreast Sunfish Lepomis *Auritis* exceeded the ecological screening value in multiple fish (Appendices BB, CC). A single Rock Bass *Ambloplites rupestris* collected at Transect E also exceeded the NC cobalt screening value. In Virginia at the time of submittal of the original study plan, there was no fish tissue cobalt screening value, thus, we present the means and ranges from the Virginia sampling locations for comparison with NC locations. Most of the fish including Golden Redhorse, Largemouth Bass, Smallmouth Bass, and Redbreast Sunfish cobalt concentrations from the river locations in Virginia and all Bluegill *Lepomis Macrochirus* from Transect I, were within the ranges of cobalt concentrations at all locations. A similar pattern of cobalt accumulation was observed in fish during 2016 while no fish were observed above screening values during 2017 (Appendices DD, EE). Copper concentrations were all below the ecological screening values of both states except for two Smallmouth Bass at Transect A during 2015. Mercury in fish tissues exceeded the ecological screening values for the respective state waters only during 2017 and only eight times among three species (Appendices FF, GG). In North Carolina, only a single Largemouth Bass at Transect D was above the screening value of 0.4 µg/g wet weight. In Virginia, one Largemouth Bass at Transect F and four at Transect G exceeded that state's screening values of 0.3 µg/g wet weight. One Smallmouth Bass and one Golden Redhorse in Virginia also exceeded the screening value. Some concentrations of thallium in some fish tissues from 2015 through 2017 were observed above respective screening values in both North Carolina (0.000412 µg/g wet weight) and Virginia (0.27 µg/g wet weight) (Appendices CC, EE, GG). However, the number of exceedances were relatively few among fish species collected given the extremely low screening value for thallium in North Carolina. The exceedances occurred at all sampling transects in North Carolina including both reference sites and downstream locations. No patterns of thallium screening value exceedances appeared to be associated with the 2014 ash release to the Dan River.

Lead was measured at detectable levels from every fish sample collected during the three-year study and these are required to be reported to the respective agency for each state, depending on the collection location (Appendices BB, DD, FF). All individual lead concentration data are reported in the master trace element spreadsheets along with the other trace element concentration data on the enclosed CD.

2.4 Benthic Macroinvertebrates Community

Benthic macroinvertebrates are one of the most important components of the aquatic community and as such a major part of the Dan River LTMP. Sampling was conducted at six locations in the Dan River basin annually in the summers of 2015, 2016, and 2017. Except for Transect G, all locations were sampled using the Wadeable Stream Collection Method using NCDWR standard qualitative methods (NCDWR 2016) as described below in Table 2-1. Transect G was necessarily sampled using the Boat Sample Method (NCDWR 2016) because of greater depth, which is the same methodology except for substituting three petite ponar grabs for the kick net sampling.

Table 2-1. NCDWR standard qualitative methods (NCDWR 2016).

2016 NCDWR Standard Qualitative Methods				
Coarse-mesh (500-1000 µm)				
Habitat	**Microhabitat**	**Sampler**	**No. Samples**	**Type**
High current with structure	Riffles	Kick net	2	Single, disturbance
Low current with structure, submerged vegetation, depositional areas	Banks	Dip net	3	Composite, disturbance
Leaves	Leaf packs	Wash bucket	1	Composite, wash
Fine-mesh (300 µm)				
Habitat	**Microhabitat**	**Sampler**	**No. Samples**	**Type**
Aufwuchs	Rock and logs	U.S. Standard Sieve Size No. 50	2	Composite, wash
Sand	Sand	U.S. Standard Sieve Size No. 50	1	Composite (3), disturbance
Visual Collections				
Habitat	**Microhabitat**	**Sampler**	**No. Samples**	**Type**
NA	Large rock and logs	(10-15 minutes effort)	1	Composite

The Duke Energy benthic invertebrate rapid bioassessment procedure uses the NCDWR sampling methodology as the basis for sampling except for the use of a U.S. Standard Sieve Size No. 50, a white pan, and a winnowing technique was substituted for the NCDWR method prescribing the use of a plastic basin, PVC cylinders, and Nitex® bag. All organisms were preserved in 95% denatured-ethanol, transferred to 70% denatured-ethanol after sampling was completed, and returned to the laboratory for identification to the lowest practical level using standard taxonomic references and enumeration. Tolerance values (TV) for the taxon are also presented (if the taxa has an established TV). The relative numerical abundance of each taxon was tabulated as Rare = 1 (1-2 specimens), Common = 3 (3-9 specimens), or Abundant = 10 (≥10 specimens).

Sampling transect designation, location, description and coordinates are found in Table 1-1. Samples were sorted and identified to the lowest practical taxonomic level by Pennington and Associates, Inc. (PAI; certified in North Carolina and in possession of a letter of approval from VADEQ). The intent of generating the IBI-type metrics was not to score the sections of the Dan River but rather to present a relative comparison of macroinvertebrate assemblages between reference areas and areas downstream of the DRSS ash release. Raw data generated by this sampling and analysis program, and the benthic macroinvertebrate data will be available to stakeholders (i.e., agencies) and are found in Appendix HH.

Transect B is located above the confluence of the Dan and Smith Rivers in Eden NC. Transect C is in the tailrace of the run of the river low head dam at the Dan River Combined Cycle station in Eden North Carolina. Transect E is found approximately one mile below the ash release site at the NC Highway 700 bridge, also known as Drapers Landing, in Eden NC. Transects B, C and E are all located in Rockingham county, NC. Transect F is found at the head of Ware's Shoals in Pittsylvania County, Virginia approximately 11 river miles below the ash release site. Transects B, C, E and F are all similar in habitat type, i.e. riffle, run pool, with boulder and cobble and some woody debris. All four of these Transects are in the Northern Inner Piedmont (NIP) ecoregion of North Carolina and Virginia (USEPA 2018). Transect G is also in the NIP and is in the impounded area above Schoolfield Dam in Danville VA approximately 20 miles below the ash release site. Transect G is more lentic than lotic and characterized by depositional shoreline (fine clay and sand) and woody debris. Transect H is located on the boundary of the NIP and the Carolina Slate Belt ecoregions and is approximately 75 miles below the ash release site. Transect H is characterized by mostly sandy shoal substrate with woody debris, root mats and some Black Willow habitat. (Pictures and maps of all sampling transects are found in enclosed CD).

For purposes of this report Transects B and C are considered as reference stations for potentially impacted Stations E and F due to their location above the ash release site. Transect G will not be compared directly to the reference stations due to the sampling methodology used and the difference in habitat types. Transect H will not be compared directly to the reference stations based on the slight ecoregion differences and the station's distance from the reference stations. Ancillary transect water quality information collected on the day of sampling is provided in Table 2-2.

Table 2-2. Transect sampling date(s) and water quality data recorded on that date.

Transect	Sample Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm)	pH	Turbidity
B	9/18/2015	20.2	7.6	182	8.0	NR[1]
B	9/12/2016	24.9	7.9	106	7.9	7.7
B	9/18/2017	22.5	7.7	108	7.6	9.6
C	10/15/2015	20.0	9.1	128	7.7	16.0
C	9/13/2016	22.9	8.2	133	7.5	11.0
C	9/20/2017	22.0	8.3	101	7.7	6.7
E	10/15/2015	21.4	9.0	117	7.5	12.0
E	9/13/2016	23.3	8.7	130	7.5	6.0
E	9/20/2017	23.1	8.6	101	7.6	5.6
F	7/21/2014	26.7	8.6	126	7.9	3.3
F	7/24/2015	22.2	8.6	152	7.3	9.9
F	9/16/2016	24.0	7.6	136	7.7	6.2
F	9/22/2017	22.8	7.7	90	7.5	5.7
G	9/16/2015	24.7	8.6	145	7.8	11.0
G	9/15/2016	25.4	8.0	144	8.0	11.0
G	9/21/207	23.9	8.5	105	7.9	10.0
H	9/17/2015	20.2	8.2	130	7.5	11.0
H	9/14/2016	22.2	8.0	133	7.7	10.0
H	9/19/2017	23.8	7.8	128	7.6	15.0

[1] NR = indicates that parameter's information was not recorded on that date

Multiple descriptors are summarized for each transect sampled between years in Appendix HH. These descriptors provide a non-statistical comparison between years for those transects. Tolerance Values (TV) used for comparison are taken from NCDWR standard qualitative methods (NCDWR 2016). The entire list of individual taxa TVs can be found in the raw data listing on the enclosed CD.

EPT (Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]) relative numbers and percentage of the benthic community have been used by researchers as indicators of the relative health of the benthic communities (Hilsenhoff 1977, 1981, 1987). The greater the percentage of EPT the greater the likelihood of the community being diverse and healthy. Tolerance values indicate that taxa's ability to withstand polluted waters. TVs for individual taxa are ranked from 0.0 (intolerant) to 10.0 (tolerant). Tolerance Values (TVs) along with percent EPT have been used by multiple state and federal agencies in developing and establishing criteria for scoring a benthic community's relative health. TVs used in this report are taken from NCDWR standard qualitative methods (NCDWR 2016). It should be noted that there are numerous taxa that do not have an assigned TV. The percentage of those individuals for EPT and non-EPT is shown for each transect in Appendix HH. The percentage of those taxa with no TVs that are EPT is also listed. This percentage is presented to emphasize the fact that a considerable number of EPT were found in the taxa with no designated TV. For purposes

of this report, collected taxa were artificially split into three groups and defined as: intolerant taxa (0.0 - ≤ 3.3 TVs), intermediate taxa (≤ 6.7-3.3 TVs) and tolerant taxa (≤ 10-6.8 TVs). Those taxa without TVs will not be used in the discussion of the relative tolerance for each transect.

Comparisons of the percentage of EPT for all collected taxa between years by station and the average percentage for the three years are presented in Table 2-3.

Table 2-3. Percent EPT taxa by Transect location in the Dan River from 2015-2017.

Year	Transect					
	B	C	E	F	G	H
2015	42.3%	30.7%	43.0%	43.0%	20.5%	40.9%
2016	36.5%	36.6%	35.8%	42.7%	23.8%	37.0%
2017	36.8%	35.4%	44.4%	36.5%	27.9%	31.8%
Average	38.5%	34.2%	41.1%	40.7%	24.1%	36.6%

The percentage of EPT varies little between years and between stations. Please note that the average percentage EPT for the likely impacted stations (Transects E and F) are higher than either of the control Transects B and C. These numbers indicate that there was no long-term impact to the potentially impacted communities. Transect G had relatively low numbers of taxa for each year sampled (Table 2-3). While percentage EPT was lower in comparison to the other five transects, there was still an average of 24.1 % EPT an indicator that the community at this transect was healthy. Transect H exhibited robust EPT percentages comparable with all other transects EPT percentages except for Transect G.

Comparisons of the percentage of intolerant, intermediate and tolerant taxa for all taxa that have assigned TVs between years and by station and the average percentage for the three years are presented in Table 2-4.

Table 2-4. Percent intolerant, intermediate and tolerant taxa by transect location in the Dan River from 2015-2017.

Percent intolerant taxa of total taxa by transect (TV 0.0 ≤ 3.3)						
Year	**B**	**C**	**E**	**F**	**G**	**H**
2015	15.7%	15.0%	17.1%	15.5%	6.8%	12.5%
2016	12.2%	11.3%	12.3%	17.3%	4.8%	9.1%
2017	14.7%	10.9%	21.5%	14.9%	4.7%	9.4%
Average	14.2%	12.4%	17.0%	15.9%	5.4%	10.3%
Percent intermediate taxa of total taxa (TV 3.3 ≤ 6.7)						
Year	**B**	**C**	**E**	**F**	**G**	**H**
2015	22.9%	39.0%	46.1%	41.7%	34.1%	42.2%
2016	22.0%	36.1%	50.8%	48.1%	38.1%	52.7%
2017	21.3%	34.7%	49.2%	56.8%	46.5%	48.4%
Average	22.0%	36.6%	48.7%	48.9%	39.6%	47.8%

Table 2.4 (cont.)

Percent tolerant taxa of total taxa (TV 6.7 ≤ 10)						
Year	**B**	**C**	**E**	**F**	**G**	**H**
2015	22.9%	18.0%	18.4%	16.7%	29.5%	20.3%
2016	22.0%	16.5%	21.5%	13.6%	28.6%	21.8%
2017	21.3%	15.8%	10.8%	12.2%	25.6%	17.2%
Average	22.0%	16.8%	16.9%	14.1%	27.9%	19.8%

Like the percentage of EPT, percentages of intolerant, intermediate and tolerant taxa varied little between years and between stations. Again, the average percentage intolerant taxa for the potentially impacted stations (Transects E and F) are higher than either of the control Transects B and C. These numbers again indicate that there was no long-term impact to the potentially impacted communities. Transect G had lowest percentage of Intolerant taxa for each year sampled. Transect H exhibited the next lowest percentage Intolerant taxa percentages but are still in line with all other Transect percentage intolerant taxa with the except for Transect G.

2.5 Fisheries

2.5.1 Methods

Boat electrofishing was conducted four times (seasonally) each year at seven locations during daylight hours on the Dan River and Kerr Lake at Transects A, B, D, E, F, G, and I (Figure 1-1, Table 1-1). Each sampling site, i.e. transect, was designated by an upstream beginning and downstream ending stretching from bank to bank. Each transect consisted of two stations, one on each bank. Most stations were further divided into three replicates each consisting of 200–300 m distances (depending on the size of the reach) for a total of six replicates. However, Transects A and F had a mid-channel station associated with shoals/riffles located at the upstream portion of the transect. These transects consisted of five replicates, whereas the other transects (B, D, E, F, G, I) consisted of six stations replicates. Each station was sampled using a Smith-Root equipped, Wisconsin-design electrofishing boat with pulsed DC current. In the river, the station replicates were generally staggered in an alternating fashion from one bank to the other to minimize recapture of released fish (not applicable to Kerr Lake due to the distance across the lake).

During the mid-summer sampling periods (July or August), additional sampling methods were used to ensure that the fish community was adequately sampled at the site and included a Duke wadeable 1.8 m pram electrofisher, a backpack electrofisher combined with a 3 m by 8 m seine with 0.32 cm mesh (kick seine method), 1.2 m hoop net with 6 m wings-3.8 cm bar mesh, 0.8 m D-hoop net (9 m by 0.8 m with 2.5 cm mesh lead, 3.8 cm mesh from hoop 1 to hoop 2 and 2.5 cm mesh from hoop 2 to the cod end), and a 6 m flat seine (0.32 cm mesh).

Four D-hoop nets were used at Transects A, D, E, and F and four three-wing fyke nets were used at Transects B, G, and I during the summer sampling period. The nets were set for two consecutive days and fished for approximately 24-hour intervals. Catch by species per 24-hour sets were calculated.

A Smith-Root Model 15 backpack electrofisher with a hand-held anode and rattail cathode used in tandem with a 0.32-cm kick seine (3.1-m in length and 1.8-m in depth) to

adequately sample the shoal/riffle-dwelling species (e.g., darters, madtoms, etc.) that inhabited rock crevices. One to two individuals vigorously kicked the substrate to disturb fish while two other individuals held the kick seine downstream of the sample area to collect stunned fish. Sampling time was approximately one minute per sample with four to six total samples collected from riffle areas.

The shallow shoreline areas of limited boat access (i.e., Transect A) were also sampled using a flat seine. No other locations had areas suitable for conducting seine hauls.

A wadeable electrofishing pram was utilized in the shoals/riffle habitat (both Transect A and F) when low water flow conditions existed and did not allow use of the boat electrofisher effectively. The pram electrofisher consisted of two hand-held anodes powered by a Smith-Root 2.5 GPP electrofisher box and a 2500 W generator. The cathode plate was attached to the pram bottom. Pulsed DC current at 2-3 amps was used during low flow events to sample both the normal replicates of both shorelines and the mid-channel to effectively sample both shoal/riffle and pool habitat.

2.5.2 Fish Species Composition and Richness

Approximately 32,000 fish were collected in the Dan River and Kerr Reservoir from 2015 to 2017 at all transects representing 13 families and 72 species of fish. Throughout the river and in the headwaters of the reservoir, the fish communities were diverse and well balanced with respect to predator and prey species.

At Transect A, 32 fish taxa representing 6 families were collected during 2015 totaling 2,261 fish (Appendix II). This reference location served primarily as comparison for Transect F downstream of the DRSS ash release site due to the similarity of habitat (shoals, riffles, and fast-moving water as well as slower moving pools) found at both locations. The carps and minnow family (Cyprinidae) numerically dominated the fish community (1,286 individuals) at this reference site with six fish species. White Shiner *Luxilus albeolus* was collected in large numbers (536) followed by Rosefin Shiner *Lythrurus ardens* (265). The North American catfishes family (Ictaluridae) was second most abundant taxa group collected in 2015 with four contributing species, 71 % being comprised of Snail Bullhead *Ameiurus natalis*. The sunfish family (Centrarchidae) ranked third numerically at Transect A, however, Redbreast Sunfish completely overshadowed other members of this family comprising 82 % of the 356 centrarchids collected. Only two other centrarchid species, the apex predators Smallmouth Bass (63) and Largemouth Bass (1), were collected here. Catostomidae (suckers) followed the sunfish family with nine species totaling 183 total fish. Blacktip Jumprock *Moxostoma cervinum* was the most abundant (71) catastomid followed Golden Redhorse (35) Northern Hogsucker *Hypentelium nigricans* (24) and Bigeye Jumprock *Scartomyzon ariommus* (21). Finally, Percidae deserves mentioning in the discussion regarding abundance at Transect A. Three intolerant species including Roanoke Darter *Percina roanoka* (22) followed by Riverweed Darter *Etheostoma podostemone* (15), Chainback Darter *Percina nevisense* (8) and the intermediate Fantail Darter *Etheostoma flabellare* (7) rounded out this family. All other species present at Transect A were very minor components of the fish species composition including a single Brown Trout (intermediate) collected only at this location during 2015.

Transect B was a comparative reference location for river run habitat locations like most of the habitat at Transects D and E as well as the downstream portions of Transect F. The total number of fish species observed at Transect B was 28 species coming from five families collected during 2015 (Appendix II). Catostomidae was the most abundant family (505 total fish) with Golden Redhorse (289) and V-lip Redhorse *Moxostoma pappillosum* (184) as the largest contributors to the total fish numbers. Centrarchidae was

second in dominance at Transect B with Redbreast Sunfish (321) as the major component followed by Largemouth Bass (39) and Smallmouth Bass (19). Cyprinidae (288) contributed notable numbers to the overall fish abundance at Transect B. White Shiner (120) was caught in the greatest number from this family followed by Comely Shiner *Notropis amoenus* (57), Spottail Shiner *Notropis hudsonius* (29), Bull Chub *Nocomis raneyi* (28), and Rosefin Shiner (21). Again, other minor groups rounded out the total fish species at Transect B.

Transect D, the site of the ash release during 2014, was one of the two greatest species richness locations during 2015 with 36 different species collected totaling 1,195 fish (Appendix II). Cyprinidae again were dominant at this transect yielding 629 individual fish (53% of the total fish). White Shiner (252) and Bull Chub (147) were the most abundant cyprinids at the location during 2015. Centrarchidae (246), Catostomidae (236), and Ictaluridae (50) were the next three largest families of fish species in that order at Transect D. Notable individual fish species in terms of total number from these families were White Shiner (252), Redbreast Sunfish (157), Largemouth Bass (25), Golden Redhorse (110), V-lip Redhorse (72), and Snail Bullhead (21). Other fish species deserving mention from location were the Margined Madtom *Noturus insignis* (11; intolerant) and Gizzard Shad *Dorosoma cepedianum* (25; not present upstream of this location). While Transect D had eight more species during 2015, in terms of the major species present, it was similar to the reference location Transect B overall. locations.

Transect E mirrored Transect D in numbers (1,081) and species (32) present during 2015 (Appendix II). The family ordering by decreasing total numbers were Cyprinidae (448), Centrarchidae (383), and Catostomidae (217). Fewer ictalurids were collected at Transect E compared to Transect D and the upstream reference locations. The major species ordering similarly were Redbreast Sunfish (252), White Shiner (217), Golden Redhorse (153), Comely Shiner (75), and Rosefin Shiner (67). Black Crappie *Pomoxis nigromaculatus* (36) and White Crappie *Pomoxis annularis* (8) became a little more prevalent in the catches at Transect E relative to upstream locations.

Transect F, which has a significant shoal/riffle (Wares Shoal) habitat in the upper portion of the transect, exhibited some minor shifting of species dominance compared to the preceding upstream stations during 2015 (Appendix II). There were 35 species and 1,527 individual fish collected at Transect F. Cyprinidae (878) was the most abundant family of fish at Transect F contributing (57%) to the total number, like observations elsewhere. This group was followed by Centrarchidae (169), Catostomidae (155), and Ictaluridae (152) in decreasing order. Like Transect A, White Shiner (284) and Bull Chub (230), respectively, showed the greatest abundance. These species were followed by Margined Madtom (137), Roanoke Darter (127) Bluehead Chub *Nocomis leptocephalus* (127), Redbreast Sunfish (122).

Transect G, which was almost reservoir-like in terms of flow and water depth, had the fewest total fish (896) of all transects and 32 species collected during 2015 (Appendix II). Centrarchidae was the dominant family with 44 % of the individuals comprised mostly of Bluegill (18%) rather than Redbreast Sunfish seen at other locations upstream. Cyprinidae contributed the second greatest number of fish (37%) at the transect. Spottail Shiner *Notropis hudsonius* (146) replaced the White Shiner as the dominant cyprinid noted upstream. Largemouth Bass (67) was the most prevalent predator Golden Redhorse (82) and Gizzard Shad (45), and Redear Sunfish were moderately abundant at Transect G. The notable shift of the species dominance at the location was partially due to reservoir-like conditions.

Transect I, in headwaters of Kerr Reservoir, had a fish community which reflected the large reservoir habitat. As observed throughout the Duke Energy reservoir systems, Centrarchidae (1,056) and Bluegill (699) dominated the total catch during 2015 (Appendix II). Gizzard Shad (454) represented the second most abundant prey fish species and the primary open water schooling species. In decreasing order, Largemouth Bass (156), Redear Sunfish (87), Blueback Herring *Alosa aestivalis* (75), Satinfin Shiner *Cyprinella analostana* (69), and Notchlip Redhorse *Moxostoma collapsum* (70) were the next five most prevalent species in Kerr Reservoir. The remaining minor species again were again typical of reservoir fish communities.

During 2016 and 2017, the species composition at each transect were dominated by the same five or six primary species as that observed there during 2015 (Appendices JJ and KK). The dominance pattern at the fish family taxonomic level appeared to be almost identical to that of 2015 as well. However, there were a few notable changes in individual species numbers and dominance deserving mention. For example, Comely Shiner displaced White Shiner at Transect B as the most prevalent cyprinid during 2016. Also in 2016, Threadfin Shad *Dorosoma petenense* (854) emerged as the most abundant clupeid with Gizzard Shad (755) following closely behind. Total fish numbers (4,094) almost doubled at Transect I during 2016 and 2017 compared to 2015. The higher total fish number was driven primarily by Bluegill (1,496) for 2016 and by Threadfin Shad for 2017. These observations are typical of fish community dynamics in rivers that experience normal environmental variations such as floods and drought. The fish communities at each of the transects were not only shaped by local habitat, but also by the habitat differences moving from upstream (Transect A) to downstream (Transect H). Species were gained moving downstream while others dropped out. The fish communities followed a longitudinal succession similar to the pattern noted by Rohde et al. (2001). Total species richness across all three years at each transect were within a few species difference from each other, consistent with a lack of impact from the ash DRSS release.

2.5.3 Analysis of Fish Community Similarity and Diversity

As stated above, observation of the fish communities at each location suggests they were stable and similar during the three-year study (i.e., no degradation occurred following the ash release). To determine the validity this, further investigation was required. Multivariate analysis using Bray-Curtis similarities, non-metric multi-dimensional scaling, and cluster ordinations of the fish communities were conducted using Primer-E v7 (Clark et al. 2014). To generate a complete picture of the fish community at each transect and remove seasonal influences, fish abundances at station replicates were averaged across seasons for each transect. To prevent high abundant species from dominating the community and to allow the lower abundant species to be accounted for when analyzing differences in the fish community over time, the abundance data were dispersion weighted and then square root transformed. The abundances were then used to generate Bray-Curtis similarity matrices for all the transects and years. The data were then subjected to hierarchical cluster analysis (i.e., dendrogram of transects displayed separately by year) and to non-metric multi-dimensional scaling. Three major spatial breaks in the fish assemblages below 60 % similarity resulted in four ultimate groupings of similar assemblages occurring at the same transects for the three years 2015 through 2017 (Figure 2-1). The dendrogram also shows a distinct pattern of the fish community composition changing, as habitat changed when moving from upstream (Transect A) to downstream (Transect I) by gaining a few species while at the same time losing a few species. Had there been an impact (i.e., changes in fish abundances or community composition from year to year) from the coal ash release, the dendrogram should have

detected the impacted locations grouping out separately below 60% similarity rather than remaining similar over time in the same groupings.

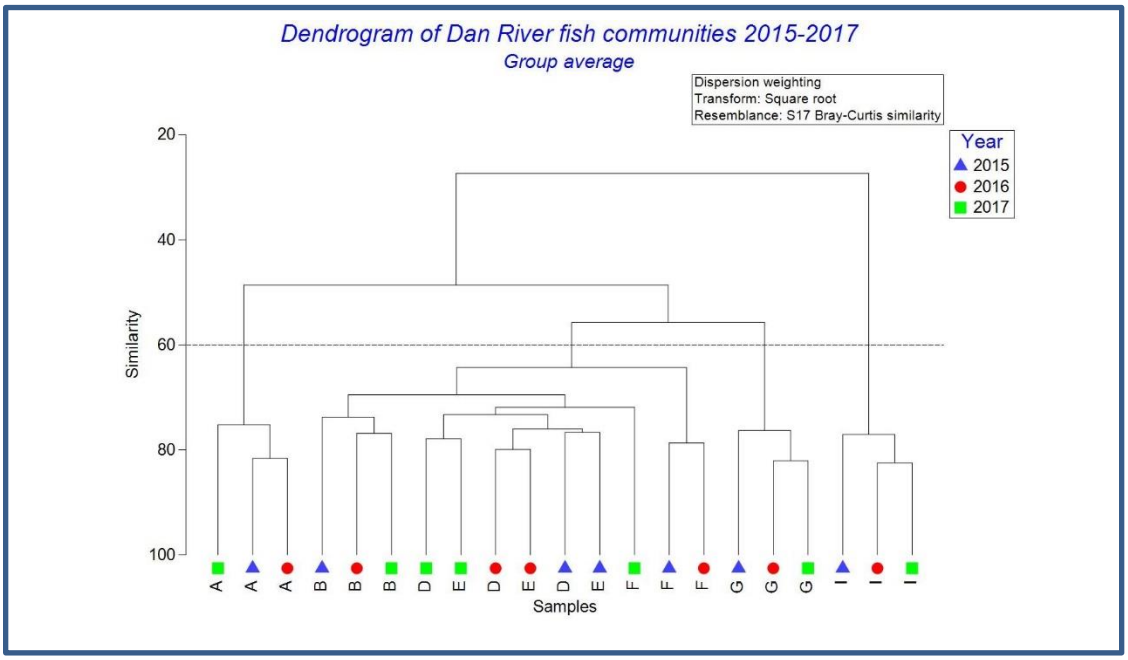


Figure 2-1. Dendrogram of fish assemblages at transects of the Dan River and Kerr Reservoir from 2015-2017 from Bray Curtis similarities (square root-transformed species abundances).

To further visualize the fish assemblages at each transect over years, a Bray-Curtis similarity matrix was then used to perform a non-metric multidimensional scaling (nMDS) ordination to extract spatiotemporal patterns of the fish community structures (i.e., transects displayed separately by year on the same plot). Four similarity levels (i.e., 20, 40, 60, and 80 percent) were superimposed on the nMDS output plot to help identify the resulting transect/year groupings (Figure 2-2). The nMDS plot showed clear differences and similarities in fish assemblage structures among the locations. Again, the reference location Transect A grouped together from 2015 through 2017. The 2015 and 2016 fish assemblages showed particularly strong spatiotemporal grouping at the 80 % similarity level as well. The largest spatiotemporal similarity grouping of fish assemblages included the reference location Transect B, and Transects D, E, and F, all downstream of the DRSS ash release site, all contained within a 60 % similarity ellipse. Transect F grouped higher vertically (i.e., closer to Transect A) likely due to the similar shoal/riffle habitats at each location. Transects D and E grouped tightly over the three years whereas Transect G fish assemblage grouped alone within a 60 % similarity ellipse. Finally, the fish assemblages in Kerr Reservoir headwaters at Transect I grouped relatively tightly together but at the extremely lower right quadrant of the ordination plot.

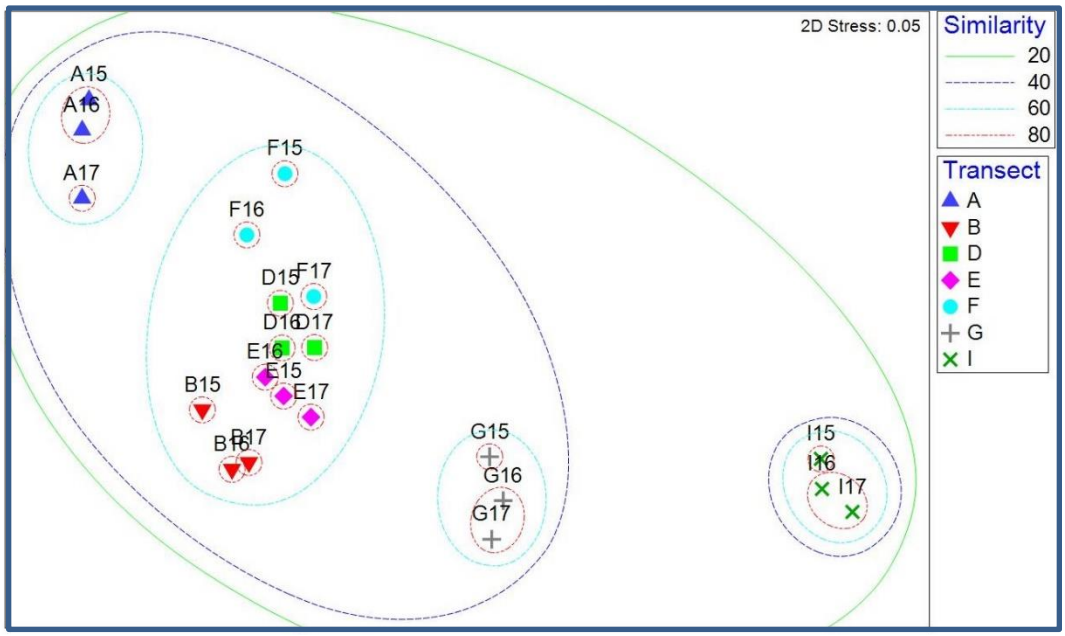


Figure 2-2. Non-metric multi-dimensional scaling plot of fish assemblages at sampling locations on the Dan River and Kerr Reservoir from 2015-2017 from Bray Curtis similarities (square root-transformed species abundances).

The spatial groupings of the fish assemblages from 2015 to 2017 (Figure 2-3) also revealed a pattern consistent with that observed by Rohde et al. (2001) indicative of longitudinal succession of species from upstream to downstream across physiographic provinces (Figure 2-3). The Rohde fish assemblages and Duke Energy fish assemblages align closely along the successional changes from upstream to downstream where the respective sampling locations from both studies were in close proximity to each other. For example, the fault basin sites from the Duke study (B, D, E, F) also grouped with Rohde (2001) fault basin localities.

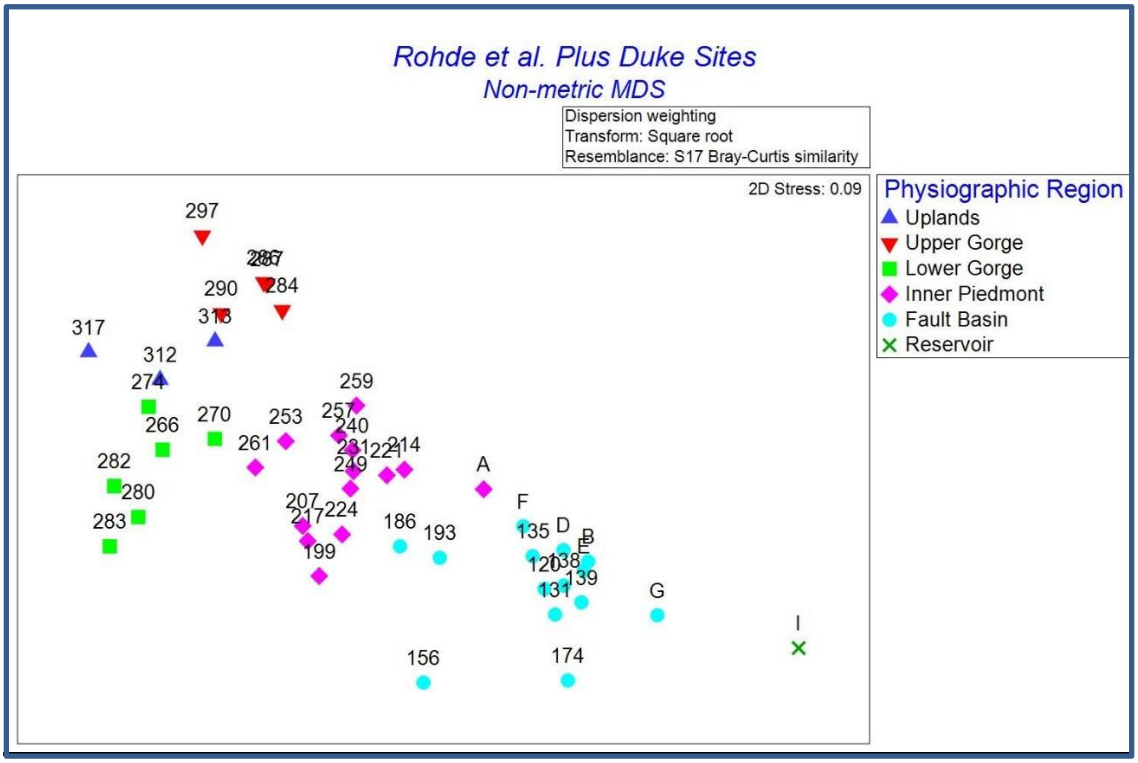


Figure 2-3. **Non-metric multi-dimensional scaling plot of Rohde et al. (2001) fish assemblage data (numeric locations) and Duke Energy 2015-2017 (alphabetic locations) fish assemblage data showing longitudinal successional changes from upstream to downstream. The Duke Energy fish assemblages fell closely within the expected spatial position representative of the longitudinal succession across physiographic provinces**.

Comparing Shannon-Wiener diversity indices and Pielou's Evenness by transect and year showed little difference in these metrics at all locations throughout the entire study (Table 2-5). These observations further strengthen the assertion that no long-term impacts to the aquatic community were evident following the DRSS ash release.

Table 2-5. Shannon-Weiner Diversity Index (Natural Log) and Pielou's Evenness calculated for the fish assemblage by transect by year.

		# of Species	# Collected	Pielou's Evenness	Shannon-Weiner Diversity Index (Natural Log)
Transect	**Year**	**S**	**N**	**J'**	**H'(loge)**
A	2015	32	2261	0.71	2.47
B	2015	28	1247	0.68	2.27
D	2015	36	1194	0.76	2.73
E	2015	32	1081	0.71	2.47
F	2015	37	1528	0.74	2.67
G	2015	31	844	0.75	2.57
I	2015	37	2033	0.64	2.30
A	2016	27	1270	0.82	2.70
B	2016	29	1075	0.73	2.46
D	2016	35	1031	0.76	2.70
E	2016	34	1228	0.69	2.45
F	2016	30	968	0.77	2.62
G	2016	30	1329	0.78	2.66
I	2016	38	4093	0.56	2.04
A	2017	26	1815	0.78	2.53
B	2017	31	1259	0.64	2.19
D	2017	35	1455	0.70	2.50
E	2017	30	1245	0.69	2.33
F	2017	33	1201	0.76	2.65
G	2017	29	1151	0.73	2.47
I	2017	31	3990	0.57	1.95

2.5.4 Reproduction, Recruitment and Health of Representative Important Species

Representative Important Species (RIS) were assigned at each transect (based on availability) to serve as indicator species for the existing fish community at each transect for the metrics of reproduction, recruitment, and condition factor. An attempt was made to select consistent RIS across transects, however, longitudinal succession changes of species abundance resulted RIS variation. This variation was particularly evident moving from the Dan River into Kerr Reservoir. The RIS were selected from differing fish families, trophic guilds, and pollution tolerance ratings to represent a cross section of the fish assemblages. The metrics of these species were assessed against the metrics of the same species at other locations where present in sufficient numbers The RIS include Bull Chub, Golden Redhorse, Smallmouth Bass, and White Shiner (Transects A, B, D, E, and F); Golden Redhorse, Smallmouth Bass, and White Shiner (Transect G); and Bluegill, Gizzard Shad, Largemouth Bass, and Notchlip Redhorse (Transect I). Young-of-year (YOY) and remaining multiple age class fish (Age 1+) for each species were generally based on total length size categories from Carlander (1969).

Reproduction and Recruitment of RIS

Bull Chub were collected in relatively large numbers at Transect A each year from 2015 through 2017 (Appendix LL). Both reproduction, as indicated by presence of YOY fish (< 75 mm) and recruitment as indicated by the presence of Age 1+ fish (≥ 75 were good during the study. White Shiner were collected in very large numbers during 2015 and more moderate numbers in both 2016 and 2017 (Appendix MM). Most individuals of this species were YOY (< 75 mm) during 2015 but the length frequency (LF) displayed a bimodal distribution with good numbers of Age 1+ fish (≥ 75 mm). Reproduction and recruitment were again observed during 2016 and 2017 with adequate YOY fish and age class 1+ fish present. Golden Redhorse YOY (< 100mm) were present at Transect B during 2015 but were not collected during 2016 and 2017 (Appendix NN). However, recruitment into age class 1 and above appeared to be good. Redbreast Sunfish were collected in large numbers as well during each year of the study and filled out the sizes classes for YOY (< 80 mm) and age classes 1+ (≥ 80 mm) (Appendix OO). Smallmouth Bass sizes classes for 2015 and 2016 included YOY (< 150 mm) and age class 1+ (≥ 150 mm) fish (Appendix PP). Based on the LF distributions of the Transect A RIS, the fish community at this location appeared to have good predator-prey balance and sustainability.

Bull Chub were collected in small numbers each year at Transect B (reference location) (Appendix LL). During 2015, YOY were collected indicating successful reproduction but YOY fish were not collected in either 2016 or 2017. The result could have been related to several factors including deep water level (this location is upstream of the low head dam at DRSS) combined with geartype efficiency for this species and higher flow conditions as the Transect begins at the confluence of the Dan River and the Smith River. Recruitment into Age 1+ year classes from 2015 through 2017 for Bull Chub appeared to be reasonable. At Transect B, White Shiner exhibited classic bimodal length frequency distributions from 2015 through 2017 indicating both good reproduction and recruitment of this RIS at Transect B (Appendix MM). Golden Redhorse also exhibited a bimodal FL distribution during 2015 and 2016 with few YOY fish collected those years. In 2017, no YOY fish were collected but large numbers of Age 1+ fish were collected (Appendix NN). Redbreast Sunfish were present in large numbers that were well spread over the size classes, therefore, reproduction and recruitment of the RIS were good (Appendix OO). Very few Smallmouth Bass were collected at Transect B during 2015 through 2017, yet individuals in the YOY size class and Age 1+ size classes were collected (Appendix PP). Again, sampling efficiency may have affected the catch of Smallmouth Bass.

At Transect D, the site of the DRSS ash release, Bull Chub were collected in numbers between those collected at the two upstream reference locations from 2015 through 2017 (Appendix LL). YOY fish were collected in 2015 and 2017 and none were collected in 2016, yet good numbers of Age 1+ fish were observed each of the three years during the study. The LF distributions were more spread out across size classes during 2015 and 2017 but more consolidated between 100 mm to 250 mm during 2016. Reasonably large numbers of YOY and Age 1+ White Shiner were collected during 2015 through 2017 indicating reproduction and recruitment were successful at this location downstream of the ash release (Appendix MM). Golden Redhorse were observed in moderately large numbers at Transect D from 2015 through 2017(Appendix NN). The LF distributions were bimodal in 2015 and 2016 with most fish greater than YOY size. Mostly larger fish (> 200 mm) were collected in 2017. Redbreast Sunfish, one of the dominate species in the Dan River, were collected in moderate numbers at Transect D during 2015 and 2016 and in large numbers during 2017 (Appendix OO). As observed elsewhere, the size classes included both YOY and age1+ fish and were evenly distributed in the LF histograms for

this species. Smallmouth Bass were a component of the fish community at Transect D during the three-year study but were collected in small numbers (Appendix PP). Like observed at Transect B, YOY and Age 1+ fish were collected at Transect D in small numbers indicating this RIS was reproducing and recruiting here during the study.

Bull Chub LF distributions each year at Transect E mirrored those at Transect D except with less total numbers collected (Appendix LL). The mean length for Bull Chub for both locations were within a few mm of each other indicating the same population dynamics and geartype efficiency were also at play here. Both YOY and Age 1+ fish were present in the catches during 2015 through 2017 indicating reproductive and recruitment success into larger size classes occurred. White Shiner catches and the resulting LF distributions paralleled those observed at Transect D from 2015 through 2017 (Appendix MM). The mean lengths were very close to each other between the two locations each year. Reproduction was successful and recruitment was strong into the Age 1+ size classes for White Shiner. As also observed at Transect D, Golden Redhorse exhibited bimodal LF distributions composed mostly of Age1+ with few or no YOY in the catches (Appendix NN). Both the numbers collected and the mean lengths were similar across years between the two locations. Redbreast Sunfish again produced consistent and complete LF distributions at Transect D throughout the three-year study (Appendix OO). This species reproduced and recruited well resulting in multiple age class populations at this location each year from 2015 through 2017. Consistent with the other transects, Smallmouth Bass were collected in low numbers at Transect D from 2015 through 2017 (Appendix PP). However, both YOY and Age 1+ fish were observed in the catch each year indicating reproduction and recruitment were successful.

At Transect F, Bull Chub were a major component of the fish assemblage from 2015 through 2017. Fish were spread throughout the size classes of the LF distributions each year with YOY and Age 1+ fish (Appendix LL). There were distinct modes of YOY and larger size classes during 2015 and 2017 while 2016 exhibited more of an even spread. White Shiner were collected in large numbers during 2015 and 2016 and moderate numbers during 2017 (Appendix MM). Reproduction and recruitment was successful all three years of the study. As observed at other transects, Golden Redhorse exhibited LF distributions indicative of successful reproduction and recruitment at Transect D during 2015 and 2016 (Appendix NN). The LF distributions of those years were of classical bimodal size class structure while the 2017 distribution primarily consisted of larger fish (> 200 mm). Redbreast Sunfish were collected good numbers during 2015 and they increased each year thereafter (Appendix OO). Reproduction and recruitment were successful with this RIS as well all years of the study based on YOY and age 1+sizes class abundance. As observed elsewhere, Smallmouth Bass were again collected infrequently at Transect F (Appendix PP). But as observed elsewhere as well, this RIS exhibited YOY and Age 1+ represented in their LF distributions. The RIS at Transect F were indicative a balanced and self-sustaining fish community.

Only three RIS were selected at Transect G because Bull Chub and Smallmouth Bass were unavailable. White Shiner were only a minor component of the fish assemblages at Transect G during 2015 through 2017 (Appendix MM). In 2015 and 2016, both YOY and age1+ fish were observed indicating that reproduction and recruitment were occurring in the RIS those years. Only three White Shiner of Age 1+were collected in 2017. This observation may have been due to habitat driven successional changes moving downstream. Golden Redhorse were collected in moderate numbers but only a few YOY were observed in 2015 and 2016 and no YOY were collected in 2017 (Appendix NN). There were also two distinct size class modes of age1+ fish (≥ 100 mm) observed during

2015 and 2016 while 2017 showed a single grouping above 200 mm. Redbreast continued as a dominant species of the fish assemblage at Transect G (Appendix OO). As at all other stations upstream of Transect G, reproduction and recruitment of the RIS was good from 2015 through 2017.

Transect I in Kerr Reservoir had differing RIS as mentioned above during the study. Gizzard Shad, were collected in reasonably large numbers from 2015 through 2017 (Appendix QQ). This prey species exhibited a strong pulse of YOY (< 125 mm) production and good numbers of Age 1+ (≥ 125 mm) each year. A schooling prey species such as Gizzard Shad in a reservoir is important for predator species in the larger size classes to serve as a food source for continued growth. Bluegill, an omnivore species also important as prey, had a strong presence in Kerr Reservoir from 2015 through 2017. YOY (< 80 mm) and Age 1+ (≥ 80 mm) fish were present in good numbers each year demonstrating successful reproduction as well as recruitment to larger sizes classes (Appendix RR). Notchlip Redhorse were mostly collected as larger adult fish (> 400 mm) from Kerr Reservoir from 2015 to 2017. YOY (< 100 mm) were sparsely observed during 2015 and 2017 indicating reproduction was occurring although were not efficiently captured by the geartype utilized (Appendix SS). Largemouth Bass ranged from 60 mm to 500 mm in Kerr Reservoir during 2015 through 2017 (Appendix TT). The YOY (< 150 mm) and Age 1+ (≥ 150 mm) were well represented in the catches each year verifying successful reproduction and recruitment for this predator species. The numbers of Largemouth Bass observed suggests they were sustaining and in balance with prey species.

RIS Health

Relative weight (W_r) for select RIS was calculated as an indicator of overall health and condition for comparison among locations. Weight-length regression analysis techniques (Wege and Anderson 1978) were employed for application throughout the Dan River using length/weight data from the reference locations (Transects A and B). For the Dan River, RIS included Bull Chub, Golden Redhorse, Redbreast Sunfish, and Smallmouth Bass and for the Kerr Reservoir, RIS were Bluegill, Gizzard Shad, Notchlip Redhorse, and Largemouth Bass. W_r is a unitless value where 100 is the 75th percentile of all populations. W_r values considerably higher than 100 may indicate an overabundance of prey available for the species and values considerably below 100 may indicate a lack of food or a possible an impact (Neumann et al. 2012). It is important to note that W_r values of less than 100 representing average W_r condition, while species specific, would not necessarily be indicative of fish in poor condition. For the purposes of the current study, we considered values below 80 as poor condition applicable to individual fish.

The mean W_r for Bull Chub, Golden Redhorse, and Redbreast Sunfish during 2015 through 2017 were all above 90 for Dan River transects and most mean values were at or above 100 (Appendices UU, VV, WW). On the other hand, the mean W_r values for Smallmouth Bass tended to be in the 80s for most locations from 2015 through 2017 (Appendix XX). Again, W_r values in the 80s suggest average health condition for this species. In Kerr Reservoir, W_r values for Gizzard Shad, Notchlip Redhorse, and Bluegill were all near 100 and the predator species Largemouth Bass had W_r values in the low 90s (Appendix YY). Based on the W_r values for RIS, there was no indication of health differences between the reference locations and those downstream of the ash release as well as in Kerr Reservoir during the three-year study.

2.5.5 Index of Biotic Integrity Metrics

Standard IBI metrics for fish were compiled for each location and year measures of relative environmental "well-being" without generating actual IBI scores (Tables 2-6, 2-7, 2-8). Several notable metrics were common at both the reference locations and locations downstream of the ash release each year from 2015 through 2017. These include number of taxa (richness), number of sucker species, number of intolerant species, percentages of species with multiple age groups, and low incidence of deformities/anomalies/disease. The similarity of metrics between reference locations and locations downstream of the DRSS further support the lack of long-term impacts from the ash release.

Table 2-6. IBI metrics for Dan River and Kerr Reservoir locations for 2015.

Metric	Transect A	Transect B	Transect D	Transect E	Transect F	Transect G	Transect I
1. Total number of taxa	33	28	36	32	35	32	36
2. Number of darter species	6	2	3	1	5	0	0
3. Number of (*Lepomis*) sunfish species	1	5	4	3	3	7	6
4. Number of sucker species	7	6	7	7	7	6	6
5. Number of intolerant species	5	3	2	4	3	1	1
6. Proportion of individuals as tolerant	0.12	0.18	0.19	0.22	0.20	0.16	0.17
7. Proportion of individuals as omnivores	0.15	0.18	0.25	0.28	0.23	0.06	0.22
8. Proportion of insectivorous cyprinids	0.18	0.04	0.00	0.06	0.06	0.00	0.06
9. Proportion of individuals as piscivores	0.09	0.14	0.17	0.16	0.06	0.19	0.33
10. Number of individuals	2261	1250	1195	1081	1527	896	2036
11. Percentage of species with multiple age groups	36.36	53.57	55.56	43.75	48.57	46.88	55.56
12. Deformities/anomalies/ Disease (%)	0.06	0.04	0.06	0	0.06	0.03	0

Table 2-7. IBI metrics for Dan River and Kerr Reservoir locations for 2016.

Metric	Transect A	Transect B	Transect D	Transect E	Transect F	Transect G	Transect I
1. Total number of taxa	27	29	35	34	30	31	39
2. Number of darter species	4	0	2	2	3	0	0
3. Number of (*Lepomis*) sunfish species	2	4	6	4	3	7	7
4. Number of sucker species	8	8	8	7	7	5	4
5. Number of intolerant species	4	1	4	3	2	1	0
6. Proportion of individuals as tolerant	0.15	0.21	0.17	0.24	0.13	0.26	0.26
7. Proportion of individuals as omnivores	0.15	0.24	0.23	0.32	0.23	0.35	0.20
8. Proportion of insectivorous cyprinids	0.18	0.21	0.11	0.15	0.13	0.13	0.10
9. Proportion of individuals as piscivores	0.04	0.07	0.14	0.12	0.13	0.16	0.31
10. Number of individuals	1270	1071	1031	1227	968	1333	4094
11. Proportion of species with multiple age groups	55.56	55.17	45.71	50.00	50.00	54.84	51.28
12. Deformities/anomalies/ Disease (%)	0.03	0.00	0.14	0.06	0.00	0.06	0.08

Table 2-8. IBI metrics for Dan River and Kerr Reservoir locations for 2017.

Metric	Transect A	Transect B	Transect D	Transect E	Transect F	Transect G	Transect I
1. Total number of taxa	27	33	36	30	33	31	32
2. Number of darter species	2	0	4	1	2	0	0
3. Number of (*Lepomis*) sunfish species	3	5	5	5	4	5	6
4. Number of sucker species	8	8	8	7	7	5	4
5. Number of intolerant species	4	1	4	4	2	1	1
6. Proportion of individuals as tolerant	0.15	0.21	0.22	0.23	0.21	0.26	0.22
7. Proportion of individuals as omnivores	0.11	0.18	0.22	0.23	0.21	0.29	0.25
8. Proportion of insectivorous cyprinids	0.22	0.15	0.14	0.03	0.18	0.10	0.06
9. Proportion of individuals as piscivores	0.07	0.18	0.11	0.17	0.15	0.19	0.38
10. Number of individuals	1816	1216	1455	1245	1201	1153	3991
11. Proportion of species with multiple age groups	59.26	42.42	47.22	50.00	48.48	41.94	56.25
12. Deformities/anomalies/ Disease (%)	0.00	0.06	0.03	0.00	0.00	0.06	0.06

2.5.6 Deformities, Anomalies, and Disease

During the three-year study of potential long-term impacts of the DRSS ash release of 2014, a total of 31,943 fish were collected and examined for deformities, anomalies, and diseases. Obvious physical injuries were recorded in the field but not included in this report. Actual health related changes were rarely observed during the three-year study. A total of only 27 fish at all transects over the three-year study period were found to have some form of deformity, anomaly, and diseases with the majority being fin deformities (Table 2-9). The total observations were divided into six occurrences at the two reference locations (33%) versus 21 occurrences among five downstream locations (24%) or a slightly lower occurrence rate downstream. While the overall occurrence rate of deformities, anomalies, and disease was extremely low, it is important to stress there was no observed increase in these occurrences in the area potentially impacted by the DRSS ash release.

Table 2-9. Deformities, anomalies and disease of fish collected from the Dan River and Kerr Reservoir by transect and year, 2015-2017.

Transect	Year	Common Name	Length	Weight	Deformities/anomalies/disease
A	2015	Snail Bullhead	160	35	Scoliosis
A	2015	Snail Bullhead	223	130	Scoliosis
B	2015	Golden Redhorse	295	275	Deformed mandible
D	2015	V-lip Redhorse	260	141	Cranial deformity
D	2015	Snail Bullhead	199	89	Scoliosis
F	2015	Redbreast Sunfish	154	58	Depressed cranium
F	2015	Golden Redhorse	326	326	Wavy caudle fin
G	2015	Common Carp	590	3,150	Wavy right pectoral fin
A	2016	Golden Redhorse	319	319	Pectoral fin bud on right side
D	2016	Smallmouth Bass	245	168	Lesion on caudle peduncle
D	2016	Largemouth Bass	360	694	Opercular lesion
D	2016	Bluegill	143	48	Red sore disease
D	2016	Golden Redhorse	309	274	Pughead
D	2016	Golden Redhorse	340	409	Pughead
E	2016	Largemouth Bass	323	404	External Parasites
G	2016	Common Carp	529	2,200	First pectoral fin rays abbreviated each side
G	2016	Golden Redhorse	346	369	Deformed cranium
I	2016	Common Carp	725	6,800	Missing right eye. Pectoral fins abbreviated.
I	2016	Notchlip Redhorse	295	266	Wavy caudal and dorsal fins
I	2016	Bluegill	172	108	Unknown growth or swelling of musculature
B	2017	Common Carp	910	12,250	Wavy pectoral and pelvic fins
B	2017	Common Carp	775	7,600	Wavy caudle, pectoral, and pelvic fins
D	2017	Common Carp	802	8,700	Wavy right pectoral fin
G	2017	Common Carp	585	2,550	Wavy pectoral fins
G	2017	Common Carp	745	4,900	Wavy pectoral fins
I	2017	Common Carp	617	3,050	Wavy left pectoral fin
I	2017	Largemouth Bass	449	1,400	Caudal fin and lower jaw deformity

Because of the extremely small number of deformities/anomalies/disease observed during the three-year study and the fact that they occurred at both the upstream reference sites and the sites downstream of the ash release, they were considered unrelated to the DRSS ash release. Below are a few examples of the fish collected and photographed with deformities and lesions (Figure 2-4). All fish photographed for deformities/anomalies/disease are also available on the enclosed CD.

Figure 2-4. Examples of fish with deformities, anomalies and disease. Upper left-lower jaw deformity, upper right-lesion anterior of caudal peduncle, middle left-caudal fin deformity, middle right-missing right eye, lower left-upper mandible deformity, lower right-caudal fin erosion.

3 Summary and Conclusions

Following the DRSS coal ash release on February 2, 2014, Duke Energy began intensive monitoring of the aquatic environment for three consecutive years based on a previously submitted study plan. Sampling commenced early in January of 2015 and continued through the end of 2017, to assess whether a degradation of water quality and the aquatic community occurred downstream of the release. The monitoring program was designed to assess potential impacts of coal ash to the Dan River and Kerr Reservoir. Specifically, the monitoring program focused on water quality, water chemistry (including potential ash-related trace elements, such arsenic and selenium), trace elements in sediments and various biota, and the health of two major components of the aquatic community, benthic macroinvertebrates and fish. The findings of monitoring program indicated that no impacts were occurring in the system during the study that could be directly or indirectly linked to the ash release. Where limited ecological data such as certain trace elements in biota suggested there could be intermittent or on-going possible environmental impacts to the system, these were generally found throughout study area, both upstream and downstream of the DRSS and ash release point. Despite these limited observations, the Dan River and Kerr Reservoir exhibited good water quality (except for high sediment loading) and good aquatic community health. Duke Energy believes the 2014 DRSS ash release should be considered to have had no major long-term impact thus far and there is no potential for any future impacts.

4 References

Carlander (1969). Handbook of freshwater fisheries biology. Volume one. The Iowa State University Press. Ames, Iowa. Third edition.

Clarke, K.R., Gorley, R.N., Somerfield, P.J., and RM Warwick. 2014. Changes in marine communities: an approach to statistical analysis and interpretation. 3rd Edition. Primer-E: Plymouth, New Zealand.

USEPA 2018. Level III and IV Ecoregions of EPA Regions 3 and 4. (ftp://newftp.epa.gov/EPADataCommons/ORD/Ecoregions/reg3/reg3_eco_pg.pdf).

Hilsenhoff, W. L. 1977, Use of arthropods to evaluate water quality of streams, Tech. Bull. Wisconsin Dept. Nat. Resources, 100. 15 pp.

___.1982. Using a biotic index to evaluate water quality in streams. Tech. Bull. Wisconsin Dept. Nat. Resour. 132. 22 pp.

___ 1987. An improved biotic index of organic stream pollution. The Great Lakes Entomologist. Volume 20 Number 1 - Spring 1987.

NCDWR. 2016. Standard operating procedures for benthic invertebrates. Biological Assessment Unit. April 2016. NC Department of Environment and Natural Resources, Division of Water Resources, Raleigh, NC.

Neumann, R. M., C. S. Guy, D. W. Willis. 2016. Length, weight, and associated indices. In Fisheries Techniques. 3rd Edition, Chapter 14, pages 637-676.

Page, L. M., H. Espinsoa-Pérez, L T. Findley, C. R. Gilbert, R. N. Lea, N. E. Mandrak, R. L. Mayden, and J. S. Nelson. 2013. Common and scientific names of fishes from the United States, Canada, and Mexico. 7th edition. American Fisheries Society, Special Publication 34, Bethesda, Maryland.

Rohde, F. C., R. G. Arndt, S. M. Smith. 2001. Longitudinal succession of fishes in the Dan River in Virginia and North Carolina (Blue Ridge/Piedmont Provinces) Southern Fishes Council Proceedings. Number 42. July 2001.

Rohde, Fred C.; Arndt, Rudolf G.; Coughlan, David J.; and Smith, Scott M. 2003 An annotated list of the fishes known from the Dan River in Virginia and North Carolina (Blue Ridge/Piedmont Provinces). *Southeastern Fishes Council Proceedings*: No. 45.

Trout, W. E., 2003. The Dan River atlas; rediscovering river history on the Dan, Smith's and Banister. Prepared for the Virginia Canals and Navigations Society and the Dan River Basin Association, 1st Edition.

Appendix A. Spatial trends of means and ranges for selected limnological variables from near-bottom waters of Dan River during 2015.[1,2]

	Station A1		Station B1		Station C3		Station D3		Station E1	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Temperature (°C)	14.7	5.1-25.9	15.6	5.2-27.2	15.0	4.8-25.5	15.1	4.5-25.9	15.2	4.6-27.0
Dissolved oxygen (mg/L)	10.0	6.9-12.8	9.6	7.1-12.6	10.4	7.9-12.8	10.5	8.5-12.8	9.9	7.2-12.3
pH (median value)	7.0	6.5-7.4	7.0	6.6-7.6	7.2	6.7-7.6	7.4	6.6-7.6	7.3	6.5-7.4
Specific conductance (µS/cm)	77	55-158	108	75-177	101	74-142	99	73-142	97	75-131
Turbidity (NTU)	11	4.0-38	25	6.0-79	23	8.0-60	23	6.0-58	22	6.0-44
Nutrients (mg/L)										
Ammonia-N	0.04	< 0.01-0.13	0.05	< 0.01-0.18	0.04	< 0.01-0.14	0.05	<0.01-0.15	0.05	< 0.01-0.15
Nitrate + nitrite nitrogen	0.19	0.12-0.31	0.14	0.04-0.24	0.30	0.16-0.48	0.25	0.17-0.46	0.18	0.10-0.27
Total nitrogen	0.39	0.14-0.66	0.38	0.17-0.67	0.55	0.46-0.68	0.51	0.30-0.77	0.43	0.22-0.62
Total kjeldahl nitrogen	0.20	< 0.10-0.35	0.26	< 0.10-0.54	0.25	0.20-0.36	0.26	0.11-0.36	0.25	0.12-0.36
Total phosphorus	0.025[b]	0.013-0.070	0.046[ab]	0.022-0.133	0.064[ab]	0.044-0.122	0.055[ab]	0.033-0.122	0.048[ab]	0.031-0.079
Total organic carbon	2.3	1.3-5.4	3.6	1.8-8.0	3.3	1.7-6.0	2.6	1.6-5.2	2.4	1.6-5.0
Ions (mg/L)										
Calcium	4.0[e]	3.7-4.4	9.2[b]	5.5-14.5	7.6[cd]	5.3-9.5	7.9[bcd]	5.9-9.7	7.9[bcd]	5.7-10.6
Chloride	3.6[c]	3.0-4.0	15[a]	6.0-32	11[ab]	5.0-18	11[ab]	5.0-19	11[ab]	6.0-17
Magnesium	1.6[b]	1.5-1.8	3.5[ab]	2.3-5.7	3.1[ab]	2.4-3.9	3.1[a]	2.4-3.8	3.2[bc]	2.5-4.1
Potassium	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A
Sodium	< 5.0[d]	N/A	< 5.0[d]	N/A	7.2[abc]	< 5.0-8.6	6.9[bcd]	< 5.0-7.9	< 6.0[cd]	< 5.0-7.2
Sulfate	3.7[e]	3.0-4.1	6.0[bcd]	4.7-8.6	6.6[b]	5.3-7.9	6.1[bc]	5.1-7.6	5.7[cd]	4.7-6.7
Total dissolved solids (mg/L)	43[b]	36-54	92[ab]	58-132	69[ab]	30-98	66[ab]	43-81	72[ab]	50-89
Total alkalinity (mg/L as $CaCO_3$)	14[d]	13-15	19[c]	15-21	23[b]	18-28	22[bc]	18-27	21[bc]	17-24
Hardness (mg equiv. $CaCO_3$/L)	17[b]	16-18	37[ab]	23-60	32[ab]	23-40	33[a]	25-40	33[ab]	25-43

Appendix A. (cont.)

	Station F3		Station G1		Station H2		Station I3	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Temperature (°C)	15.8	5.5-26.5	16.0	5.4-27.7	16.8	4.4-27.0	17.3	4.9-28.1
Dissolved oxygen (mg/L)	9.8	7.3-12.8	9.5	7.1-12.4	9.6	5.9-12.5	9.2	7.0-12.3
pH (median value)	7.3	6.7-7.6	7.4	6.7-7.5	7.2	6.5-7.3	7.2	6.6-7.9
Specific conductance (µS/cm)	96	74-137	102.	74-120	116	84-197	135	88-197
Turbidity (NTU)	27	8.0-54	21	12-43	32	11-68	43	28-60
Nutrients (mg/L)								
Ammonia-N	0.05	< 0.01-0.18	0.06	< 0.01-0.17	0.07	< 0.01-0.20	0.07	< 0.01-0.16
Nitrate + nitrite nitrogen	0.17	0.10-0.27	0.17	0.05-0.26	0.32	0.13-0.70	0.19	0.11-0.29
Total nitrogen	0.47	0.23-0.69	0.39	0.13-0.62	0.80	0.62-1.20	0.56	0.36-0.71
Total kjeldahl nitrogen	0.29	0.13-0.54	0.22	< 0.10-0.37	0.47	0.38-0.61	0.37	0.21-0.45
Total phosphorus	0.063[a]	0.041-0.090	0.052[ab]	0.029-0.085	0.073[ab]	0.042-0.125	0.075[a]	0.047-0.104
Total organic carbon (mg/L)	2.8	1.6-5.0	2.6	1.5-5.6	3.9	1.6-6.6	3.8	2.3-7.4
Ions (mg/L)								
Calcium	8.0[bc]	5.7-11	7.6[cd]	5.5-11	6.6[d]	5.2-9.9	11[a]	6.0-13
Chloride	11[ab]	6.0-21	10[b]	5.0-18	12[ab]	6.0-34	13[ab]	8.0-24
Magnesium	3.2[bc]	2.5-4.4	3.0[bc]	2.5-4.1	2.8[c]	2.3-3.9	4.5[a]	2.7-5.6
Potassium	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A
Sodium	5.8[cd]	< 5.0-6.2	6.1[bcd]	< 5.0-6.7	9.2[a]	< 5.0-20.1	7.7[ab]	< 5.0-12.0
Sulfate	5.9[bcd]	4.6-7.1	5.6[cd]	4.6-6.7	5.4[d]	4.3-7.1	7.6[a]	5.8-9.1
Total dissolved solids (mg/L)	76[ab]	62-99	73[ab]	64-94	91[ab]	82-105	99[a]	93-112
Total alkalinity (mg/L as $CaCO_3$)	21[bc]	18-25	23[bc]	18-26	24[b]	20-30	35[a]	20-48
Hardness (mg equiv. $CaCO_3$/L)	33[ab]	24-47	32[ab]	24-44	28[ab]	22-41	45[a]	27-56

[1]Unless otherwise noted, all measurements were taken from near-bottom. Appropriate statistical testing (parametric or non-parametric) was based on dataset distributions (normality testing). Mean separations testing was applied only if the overall model test statistical for the treatment was significant. Means followed by different superscripts were significantly different from each other (P = 0.05). The portions of rows where significant differences were applicable are shaded. Data were rounded to conform to significant digit requirements. Rounding may obscure some mean differences. Sample size equaled 6 unless otherwise noted. Statistical testing was conducted on near bottom water means only. N/A means not applicable and NS means not sampled.

[2]Less than values (<) indicate the Lower Reporting Limit (LRL) for the variable. The LRL is a statistically determined limit beyond which chemical concentrations cannot be reliably quantified. Statistical analyses were utilized only when mean concentrations were above the highest analytical LRL and where LRL values occurred, the means were calculated by utilizing one half of the absolute value of each LRL.

Appendix B. Spatial trends of means and ranges for selected limnological variables from near-bottom waters of Dan River during 2016.[1,2]

	Station A1		Station B1		Station C3		Station D3		Station E1	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Temperature (°C)	15.0	3.3-25.2	15.9	4.3-26.3	15.1	5.0-24.7	15.2	5.2-24.8	15.7	3.9-25.5
Dissolved oxygen (mg/L)	10.5	7.9-13.5	9.6	7.3-12.9	10.1	8.5-12.1	10.2	8.4-13.1	10.0	8.1-13.2
pH (median value)	7.6	6.8-7.8	7.4	7.0-7.6	7.4	6.4-7.7	7.5	6.7-7.7	7.4	6.5-7.8
Specific conductance (µS/cm)	53	38-58	103	44-177	93	57-131	94	68-130	92	60-129
Turbidity (NTU)	58	2.0-321	96	3.0-521	36	7.0-158	32	7.0-134	51	7.0-252
Nutrients (mg/L)										
Ammonia-N	0.02	< 0.01-0.02	0.02	< 0.01-0.02	0.01	< 0.01-0.02	0.02	< 0.01-0.02	0.02	< 0.01-0.02
Nitrate + nitrite nitrogen	0.21	< 0.02-0.39	0.17	< 0.02-0.32	0.26	0.15-0.34	0.25	0.12-0.33	0.21	0.07-0.31
Total nitrogen	0.66	< 0.12-1.80	1.45	< 0.12-4.60	0.72	0.15-1.20	0.68	0.24-1.20	0.57	0.22-0.96
Kjeldahl Nitrogen	0.47	< 0.10-1.70	1.30	< 0.10-4.50	0.46	< 0.10-0.96	0.45	0.12-0.98	0.36	0.13-0.76
Total phosphorus	0.086	< 0.005-0.475	0.201	0.016-1.102	0.067	0.027-0.230	0.058	0.023-0.190	0.059	0.009-0.240
Total organic carbon (mg/L)	2.7	<1.0-11.0	4.0	<1.0-14.8	2.4	<1.0-7.9	2.5	1.1-7.9	3.1	<1.0-12.0
Ions (mg/L)										
Calcium	4.1[c]	3.5-4.4	9.6[a]	4.9-16.9	7.6[ab]	4.8-11.3	7.6[ab]	4.6-11.6	5.4[bc]	< 0.1-11.6
Chloride	3.7[c]	2.7-6.1	15[a]	6.0-29	9.3[b]	4.2-17	9.5[b]	4.2-18	10[b]	5.0-18
Magnesium	1.9[c]	1.4-3.6	3.5[sb]	2.0-4.9	2.9[abc]	2.2-3.6	2.8[abc]	2.1-3.7	2.6[abc]	< 0.1-7.1
Potassium	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A	< 5.0	<5.0-5.7
Sodium	< 5.0	N/A	< 5.0	N/A	< 5.0	<5.0-5.10	< 5.0	N/A	< 5.0	N/A
Sulfate	3.4[b]	2.7-4.3	6.1[a]	3.8-9.4	5.7[a]	4.7-7.1	5.6[ab]	4.8-7.1	5.4[ab]	4.6-6.8
Total dissolved solids (mg/L)	32[c]	14-52	74[ab]	22-122	64[ab]	32-89	58[b]	< 10-88	60[b]	37-83
Total alkalinity (mg/L as $CaCO_3$)	15[d]	9.0-20	19[c]	10-26	22[bc]	15-29	21[bc]	15-28	21[bc]	16-28
Hardness (mg equiv. $CaCO_3$/L)	18[d]	14-24	38[ab]	21-62	31[bc]	23-43	30[bc]	20-44	36[bc]	24-52

Appendix B. (cont.)

	Station F3		Station G1		Station H2		Station I3	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Temperature (°C)	16.0	4.5-25.6	16.5	4.5-25.8	16.6	4.1-26.5	17.6	5.5-30.0
Dissolved oxygen (mg/L)	9.8	7.4-13.0	9.6	7.3-12.9	9.1	6.6-12.7	9.0	7.4-11.3
pH (median value)	7.4	6.9-7.7	7.3	6.8-7.7	7.4	6.7-7.5	7.4	6.7-7.6
Specific conductance	94	59-133	93	56-124	92	63-125	102	65-139
Turbidity (NTU)	43	5.0-165	37	8.0-155	51	7.0-157	52	19-132
Nutrients (mg/L)								
Ammonia-N	0.02	< 0.01-0.04	0.02	< 0.01-0.03	0.02	< 0.01-0.04	0.06	<0.01-0.18
Nitrate + nitrite nitrogen	0.21	0.11-0.31	0.21	0.08-0.30	0.24	0.08-0.34	0.23	0.12-0.37
Total nitrogen	0.59	< 0.12-1.20	0.51	< 0.12-1.10	0.70	0.23-1.20	0.66	0.29-0.98
Total kjeldahl nitrogen	0.40	< 0.10-1.00	0.34	< 0.10-0.93	0.46	0.15-0.95	0.43	0.12-0.79
Total phosphorus	0.068	0.016-0.234	0.106	0.017-0.298	0.082	0.022-0.198	0.073	0.036-0.153
Total organic carbon (mg/L)	2.5	<1.0-8.4	2.8	1.1-9.0	4.0	1.7-11.4	4.0	2.1-10.1
Ions (mg/L)								
Calcium	8.0^{ab}	4.5-12	5.9^{bc}	<0.1-10	6.4^{abc}	4.9-8.2	9.6^{a}	5.1-11.8
Chloride	11^{b}	5.0-19	9.8^{b}	4.9-17.8	9.1^{b}	4.7-16	8.8^{b}	5.7-14
Magnesium	3.0^{abc}	2.2-3.8	2.3^{bc}	<0.10-3.5	2.6^{abc}	2.3-3.0	3.8^{a}	2.3-4.90
Potassium	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A
Sodium	< 5.0	<5.0-5.4	< 5.0	<5.0-5.8	5.4	<5.0-8.6	5.1	<5.0-8.1
Sulfate	5.6^{ab}	4.7-7.0	5.4^{ab}	4.7-6.8	4.7^{ab}	4.0-5.4	5.8^{a}	4.7-6.8
Total dissolved solids (mg/L)	65^{ab}	36-90	63^{ab}	26-87	73^{ab}	46-93	77^{a}	66-86
Total alkalinity (mg/L as $CaCO_3$)	22^{bc}	14-28	22^{bc}	13-30	24^{b}	15-32	35^{a}	15-45
Hardness (mg equiv. $CaCO_3$/L)	32^{abc}	21-46	29^{bc}	22-39	27^{c}	22-33	40^{a}	22-49

[1]Unless otherwise noted, all measurements were taken from near-bottom. Appropriate statistical testing (parametric or non-parametric) was based on dataset distributions (normality testing). Mean separations testing was applied only if the overall model test statistical for the treatment was significant. Means followed by different superscripts were significantly different from each other (P = 0.05). The portions of rows where significant differences were applicable are shaded. Data were rounded to conform to significant digit requirements. Rounding may obscure some mean differences. Sample size equaled 6 unless otherwise noted. Statistical testing was conducted on near bottom water means only. N/A means not applicable and NS means not sampled.

[2]Less than values (<) indicate the Lower Reporting Limit (LRL) for the variable. The LRL is a statistically determined limit beyond which chemical concentrations cannot be reliably quantified. Statistical analyses were utilized only when mean concentrations were above the highest analytical LRL and where LRL values occurred, the means were calculated by utilizing one half of the absolute value of each LRL.

Appendix C. Spatial trends of means and ranges for selected limnological variables from near-bottom waters of Dan River during 2017.[1,2]

	Station A1		Station B1		Station C3		Station D3		Station E1	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Temperature (°C)	15.4	8.1-26.2	17.6	8.2-27.3	15.7	8.8-25.7	15.7	8.8-25.8	17.1	8.7-27.2
Dissolved oxygen (mg/L)	9.9	8.2-11.6	9.3	7.4-11.7	10.2	8.0-11.8	10.2	8.0-11.7	9.7	7.6-11.9
pH (median value)	7.2	6.6-7.8	7.4	6.9-7.6	7.4	6.9-7.7	7.4	7.1-7.7	7.4	7.1-7.9
Specific conductance (µS/cm)	56[b]	54-58	103[ab]	79-137	94[ab]	78-102	94[a]	78-101	88[ab]	80-95
Turbidity (NTU)	8.5	1.8-17	14	2.8-47	12	4.3-34	11	4.0-33	11	3.8-33
Nutrients (mg/L)										
Ammonia-N	0.01	< 0.01-0.02	0.65	< 0.01-1.90	0.02	< 0.01-0.03	<0.01	< 0.01-0.02	<0.01	< 0.01-0.02
Nitrate + nitrite nitrogen	0.20[b]	0.11-0.33	0.14[b]	0.08-0.29	0.35[a]	0.25-0.63	0.34[a]	0.25-0.63	0.22[a]	0.13-0.26
Total nitrogen	0.24	< 0.12-0.45	0.18	< 0.12-0.49	0.39	0.25-0.69	0.38	0.25-0.65	0.27	0.23-0.33
Kjeldahl Nitrogen	<0.10	<0.10-0.19	0.25	< 0.10-0.31	<0.10	< 0.10-0.11	<0.10	< 0.10-17	<0.10	< 0.10-0.12
Total phosphorus	0.010	< 0.005-0.030	0.020	0.010-0.060	0.038	0.020-0.060	0.036	0.020-0.060	0.025	0.010-0.050
Total organic carbon (mg/L)	1.4[b]	< 1.0-2.0	1.5[ab]	<1.0-2.8	1.7[ab]	1.1-2.3	1.8[ab]	1.2-2.2	1.8[ab]	1.1-2.3
Ions (mg/L)										
Calcium	4.2[b]	<0.1-45.4	8.4[a]	< 0.1-11.9	7.4[a]	< 0.1-8.9	7.4[ab]	< 0.1-8.8	7.4[a]	< 0.1-8.7
Chloride	3.6[b]	3.4-3.9	11.4[a]	4.5-21.2	8.0[ab]	5.1-10.1	8.1[ab]	4.9-10.1	7.8[ab]	5.0-9.6
Magnesium	1.6[b]	< 0.1-1.8	2.9[a]	< 0.1-3.9	2.8[a]	< 0.1-3.0	2.8[ab]	< 0.1-3.1	2.7[a]	< 0.1-2.9
Potassium	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A
Sodium	< 5.0	N/A	< 5.0	< 5.0-5.4	5.7[a]	< 5.0-6.8	5.6[ab]	< 5.0-6.7	< 5.0	< 5.0-5.5
Sulfate	2.9[e]	2.4-3.9	4.6[d]	2.6-7.7	5.1[b]	4.7-5.4	4.9[bc]	4.8-5.3	4.4[bcd]	4.0-4.9
Total dissolved solids (mg/L)	41[c]	25-54	69[d]	56-92	59[b]	42-75	64[ab]	44-77	66[ab]	46-78
Total alkalinity (mg/L as $CaCO_3$)	17	13-20	24	18-26	26	22-29	25	21-30	25	22-28
Hardness (mg equiv. $CaCO_3$/L)	17[b]	16-18	33[a]	23-45	30[a]	26-34	30[ab]	27-34	30[a]	25-33

Appendix C. (cont.)

	Station F3		Station G1		Station H2		Station I3	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Temperature (°C)	16.1	8.5-27.3	16.6	8.0-28.5	16.8	9.2-26.9	17.1	7.5-29.9
Dissolved oxygen (mg/L)	10.0	7.6-12.1	9.8	7.3-11.7	9.0	6.4-11.3	9.5	5.6-12.3
pH (median value)	7.6	7.1-8.0	7.3	6.7-8.0	7.2	6.9-7.6	7.5	6.8-8.1
Specific conductance (µS/cm)	87[ab]	77-95	89[ab]	79-99	96[a]	61-129	124[a]	95-141
Turbidity (NTU)	11	3.7-35	11	4.9-38	64	12-228	31	25-38
Nutrients (mg/L)								
Ammonia-N	<0.01	< 0.01-0.02	<0.01	< 0.01-0.03	0.02	< 0.01-0.05	0.08	0.02-0.25
Nitrate + nitrite nitrogen	0.22[ab]	0.13-0.26	0.21[ab]	0.12-0.26	0.27[a]	0.22-0.31	0.21[ab]	0.09-0.31
Total nitrogen	0.25	0.13-0.41	0.26	0.20-0.39	0.55	0.22-1.60	0.38	0.20-0.54
Total kjeldahl nitrogen	<0.10	< 0.10-0.20	<0.10	< 0.10-0.14	0.29	< 0.10-1.3	0.18	< 0.10-0.30
Total phosphorus	0.022	0.010-0.050	0.022	0.010-0.050	0.099	0.030-0.370	0.050	0.040-0.070
Total organic carbon (mg/L)	1.8[ab]	1.2-2.2	1.7[ab]	1.3-2.1	4.1[ab]	1.8-13.3	2.5[a]	1.9-3.7
Ions (mg/L)								
Calcium	6.9[ab]	< 0.1-7.7	7.25[a]	< 0.1-8.2	6.7[ab]	< 0.1-7.6	9.8[a]	< 0.1-13.9
Chloride	7.1[ab]	5.0-9.8	7.3[b]	5.4-10.6	10.2[a]	6.0-17.7	12.0[a]	6.6-17.7
Magnesium	2.6[ab]	< 0.1-2.8	2.7[ab]	< 0.1-2.9	2.7[ab]	< 0.1-2.9	3.8[a]	< 0.1-5.1
Potassium	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A	< 5.0	N/A
Sodium	< 5.0	< 5.0-5.9	< 5.0	< 5.0-6.7	7.2[a]	< 5.0-12.3	8.1[a]	< 5.0-11.5
Sulfate	4.4[cd]	3.3-5.2	4.5[bcd]	3.5-5.2	4.4[bcd]	3.6-5.2	5.9[a]	5.1-6.8
Total dissolved solids (mg/L)	54[b]	38-77	52[bc]	35-74	80[a]	60-98	80[a]	58-95
Total alkalinity (mg/L as $CaCO_3$)	26	20-29	26	22-29	23	13-34	37	28-50
Hardness (mg equiv. $CaCO_3$/L)	28[ab]	26-30	29[a]	26-33	28[ab]	24-31	42[a]	32-56

[1]Unless otherwise noted, all measurements were taken from the surface. Fisher's protected Least Significant Difference (LSD) test was applied only if the overall F test for the treatment was significant. Means followed by different superscripts were significantly different from each other (P = 0.05). The rows where significant differences occurred are shaded. Data were rounded to conform to significant digit requirements. Rounding may obscure mean differences. Sample size equaled 6 unless otherwise noted. Statistical testing was conducted on near bottom water means only. N/A means not applicable and NS means not sampled.

[2]Less than values (<) indicate the Lower Reporting Limit (LRL) for the variable. The LRL is a statistically determined limit beyond which chemical concentrations cannot be reliably quantified. Statistical analyses were utilized only when mean concentrations were above the highest analytical LRL and where LRL values occurred, means were calculated by utilizing one half of the absolute value of each LRL.

Appendix D. Spatial trends of means and ranges for trace element variables from near-bottom waters of Dan River during 2015.[1,2]

	Station A1		Station B1		Station C3		Station D3		Station E1	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/L)										
Aluminum	361[b]	58-1640	737[b]	91-2860	659[b]	163-2500	627[b]	59-2320	605[b]	139-1630
Antimony	< 0.50	N/A	<0.50	N/A	<0.50	<0.50-0.60	<0.50	<0.50-0.60	<0.50	<0.50-0.53
Arsenic	<0.50	N/A	<0.50	<0.50-0.76	<0.50	<0.50-0.58	<0.50	<0.50-0.57	<0.50	N/A
Barium	18[d]	13-30	27[bc]	20-48	24[cd]	19-44.00	25[cd]	20-45	23[cd]	19-35
Beryllium	<0.20	N/A	<0.20	N/A	<0.20	N/A	<0.20	N/A	<0.20	N/A
Boron	<50	<50-69	314[a]	<50-680	139[bc]	<50-253	173[b]	<50-292	186[b]	59-377
Cadmium	<0.080	N/A	<0.080	N/A	<0.080	N/A	<0.080	N/A	<0.080	N/A
Chromium	0.90[b]	<0.50-3.00	1.57[b]	0.60-5.10	1.34[b]	<0.50-4.70	1.60[b]	0.60-4.70	1.44[b]	<0.50-3.30
Cobalt	<0.50	<0.50-0.70	0.56[ab]	<0.50-2.10	0.54[ab]	<0.50-2.00	0.54[ab]	<0.50-2.00	<0.50	<0.50-1.10
Copper	<1.0	<1.0-2.1	1.2[bcd]	<1.0-4.6	1.9[a]	1.2-4.0	1.8[ab]	1.1-4.0	1.2[bcd]	<1.0-2.8
Iron	686[a]	249-2490	1356[bc]	438-4510	1327[bc]	615-4130	1401[b]	419-4020	1234[bc]	682-2800
Lead	0.30[d]	<0.10-1.10	0.76[bc]	0.20-2.90	0.71[cd]	0.30-2.40	0.71[cd]	0.18-2.40	0.59[cd]	0.25-1.50
Manganese	21[c]	10-49	75[bc]	20-153	72[bc]	30-149	67[bc]	24-146	64[bc]	27-97
Mercury[3]	<0.2	N/A	0.0034	0.0010-0.0126	<0.2	N/A	<0.2	N/A	<0.2	N/A
Nickel	<0.50	<0.50-1.20	0.66 [bc]	<0.50-2.40	0.79 [bc]	<0.50-2.30	1.00 [ab]	0.50-2.30	0.71 [bc]	<0.50-1.50
Selenium	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A
Silver	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A
Thallium	<0.10	N/A	<0.10	N/A	<0.10	N/A	<0.10	< 0.10-0.12	<0.10	N/A
Vanadium	1.4[c]	<1.00-5.30	2.8 [bc]	<1.0-9.3	2.8 [bc]	<1.0-8.9	2.8 [bc]	<1.00-8.70	2.6 [bc]	<1.0-6.2
Zinc	<5.0	N/A	<5.0	N/A	<5.0	<5.0-9.0	<5.0	<5.00-9.90	<5.0	<5.0-5.4

Appendix D. (cont.)

	Station F3		Station G1		Station H2		Station I3	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/L)								
Aluminum	685[b]	85-2010	712[b]	< 10-1520	1455[a]	211-2500	1324[a]	996-1740
Antimony	<0.50	N/A	<0.50	N/A	0.50	<0.501.80	<0.50	N/A
Arsenic	<0.5	N/A	<0.5	N/A	<0.5	<0.5-0.68	<0.5	<0.5-0.67
Barium	27[bc]	20-37	23[d]	<0.20-32	33[ab]	23-47	37[a]	26-49
Beryllium	<0.20	N/A	<0.20	N/A	<0.20	N/A	<0.20	N/A
Boron	194[b]	62-417	151[bc]	<50-355	67[cd]	<50-202	94[bcd]	<50-237
Cadmium	<0.080	N/A	<0.080	N/A	<0.080	N/A	<0.080	N/A
Chromium	1.50[b]	0.60-3.90	1.04[b]	<0.50-3.20	2.47[a]	0.50-4.80	2.58[a]	1.60-3.40
Cobalt	0.57[ab]	<0.50-1.40	<0.50	<0.50-0.90	0.82[a]	<0.50-1.90	0.85[a]	0.50-1.20
Copper	1.6[abc]	<1.0-3.1	1.1[cd]	<1.0-2.7	1.9[a]	<1.0-4.0	2.1[a]	1.5-3.1
Iron	1598[ab]	450-3320	919[bc]	<50-2550	2219[a]	506-4340	2155[a]	1470-2860
Lead	0.77[bc]	0.30-1.70	0.46[cd]	<0.10-1.40	1.26[a]	0.33-2.40	1.15[ab]	0.74-1.70
Manganese	69[bc]	35-107	91[bc]	39-208	132[ac]	51-232	190[a]	57-501
Mercury[3]	<0.2	N/A	0.0026	0.0014-0.0066	<0.2	N/A	<0.2	N/A
Nickel	0.69 [bc]	<0.50-1.70	0.59 [c]	<0.50-1.50	1.18[a]	<0.50-2.20	1.20[a]	0.80-1.50
Selenium	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A
Silver	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A
Thallium	<0.10	N/A	<0.10	N/A	<0.10	<0.10-0.12	<0.10	N/A
Vanadium	2.9[b]	1.7-7.3	2.2[bc]	<1.0-5.8	5.1[a]	1.6-9.1	4.9[a]	3.5-7.1
Zinc	<5.0	<5.0-6.4	<5.0	<5.0-5.1	5.1	<5.0-8.7	<5.0	<5.0-12.6

[1]Unless otherwise noted, all measurements were taken from near-bottom. Appropriate statistical testing (parametric or non-parametric) was based on dataset distributions (normality testing). Mean separations testing was applied only if the overall model test statistical for the treatment was significant. Means followed by different superscripts were significantly different from each other (P = 0.05). The portions of rows where significant differences were applicable are shaded. Data were rounded to conform to significant digit requirements. Rounding may obscure some mean differences. Sample size equaled 6 unless otherwise noted. Statistical testing was conducted on near-bottom water means only. N/A means not applicable and NS means not sampled.

[2]Less than values (<) indicate the Lower Reporting Limit (LRL) for the variable. The LRL is a statistically determined limit beyond which chemical concentrations cannot be reliably quantified. Statistical analyses were utilized only when mean concentrations were above the highest analytical LRL and where LRL values occurred, the means were calculated by utilizing one half of the absolute value of each LRL.

[3]Mercury was measured in micrograms per liter (µg/L) by USEPA Method 245.1 except at Station B1 and G1 where mercury was analyzed by USEPA Method 1631E and reported in micrograms per liter (µg/L).

Appendix E. Means and ranges of aqueous trace element concentrations (µg/L) at sampling stations relative to aquatic life and human health screening values during 2015.

			Element			
			Aluminum		Mercury	
Screening Value*			87/8,000		0.012/NA	
Matrix	n	Transect	Mean	Range	Mean	Range
WATER	6	A	361	58-1640	< 0.20	NA
	6	B	737	91-2860	0.0034	0.0010-0.0126
	6	C	659	163-2500	< 0.20	NA
	6	D	627	59-2320	< 0.20	NA
	6	E	605	139-1630	< 0.20	NA
	6	F	685	85-2010	< 0.20	NA
	6	G	712	< 10-1520	0.0026	0.0014-0.0066
	6	H	1455	211-2500	< 0.20	NA
	6	I	1324	996-1740	< 0.20	NA

Units: µg/L
*Screening Values: Aquatic Life/Human Health
Note: Items **HIGHLIGHTED** indicate at least one or more water samples contained readings above screening values. Both the States of North Carolina and Virginia have eliminated iron from the Aquatic Life and Human Health water quality criteria/standards.

Appendix F. Number of exceedances by station of either aquatic life or human health screening values from water samples collected in 2015.

ALUMINUM	Transect A (NC)	Transect B (NC)	Transect C (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)	Transect I (VA)
Number of Samples > Screening Value	2/6	6/6	6/6	5/6	6/6	5/6	4/6	6/6	6/6

MERCURY	Transect A (NC)	Transect B (NC)	Transect C (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)	Transect I (VA)
Number of Samples > Screening Value	0/6	1/6	0/6	0/6	0/6	0/6	0/6	0/6	0/6

Appendix G. Spatial trends of means and ranges for trace element variables from near bottom waters of Dan River during 2016. [1,2]

	Station A1		Station B1		Station C3		Station D3		Station E1	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/L)										
Aluminum	2592	34-14900	3971	51-22300	1354	< 10-6790	1341	66-6730	7361[a]	< 10-43400
Antimony	< 0.50	N/A	< 0.50	N/A	< 0.50	N/A	< 0.50	N/A	< 0.50	N/A
Arsenic	< 0.50	<0.50-1.70	0.65	<0.50-2.60	< 0.50	<0.50-1.10	< 0.50	<0.50-1.10	0.94	<0.50-5.00
Barium	42	14-169	56	18-205	28	<0.10-77	31	19-76	92	<0.10-486
Beryllium	<0.20	<0.20-0.84	<0.20	<0.20-1.10	<0.20	<0.20-0.30	<0.20	<0.20-0.30	0.50	<0.20-2.50
Boron	<50.0	N/A	235.0[a]	<50.0-579.0	114.5[bc]	<50.0-278.0	121.7[bc]	<50.0-296.0	95.6[bc]	<50.0-296.0
Cadmium	<0.080	<0.080-0.090	<0.080	<0.080-0.120	<0.080	N/A	<0.080	N/A	0.090	<0.080-0.320
Chromium	4.28[ab]	<0.50-23.80	6.44[ab]	<0.50-34.90	2.48[ab]	<0.50-11.30	2.44[b]	<0.50-11.30	12.79[a]	<1.00-74.00
Cobalt	1.73[ab]	<0.50-9.50	2.26[ab]	<0.50-12.40	0.91[b]	<0.50-4.00	0.86[b]	<0.50-3.90	5.83[a]	<0.50-34.20
Copper	2.6	<1.0-13.3	3.8	<1.0-19.7	2.0	0.8-7.0	1.9	0.5-6.9	7.5	<1.0-42.6
Iron	3547	239-19300	5399	415-28600	2324	651-9590	1415	609-4420	6956	<50-39400
Lead	2.15	<0.10-12.20	3.10	0.10-17.00	1.20	<0.10-5.40	1.15	0.20-5.10	6.24	<0.10-36.40
Manganese	66	9-323	118	17-531	67	33-183	48	32-85	252	<5-1400
Mercury[3]	<0.20	N/A	0.0135[b]	0.0009-0.0730	< 0.20	N/A	< 0.20	N/A	< 0.20	N/A
Nickel	1.82[ab]	<0.50-9.70	2.49[ab]	<0.50-13.30	1.18[ab]	<0.50-4.70	1.16[ab]	<0.50-4.80	5.47[a]	<0.50-31.30
Selenium	<0.50	<0.50-0.60	<0.50	<0.50-0.80	<0.50	N/A	<0.50	N/A	<0.50	<0.50-1.60
Silver	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A
Thallium	0.10[ab]	<0.10-0.24	0.10[ab]	<0.10-0.35	<0.10	N/A	<0.10	N/A	0.20[a]	<0.10-0.67
Vanadium	7.0	<0.3-38.3	10.9	<0.3-58.0	4.6	<0.3-19.9	4.6	0.9-19.2	19.6	<0.3-113.0
Zinc	9.8[ab]	<5.0-46.4	12.2[ab]	<5.0-60.0	5.4[b]	<5.0-19.9	5.4[b]	<5.0-19.9	27.8[a]	<5.0-154.0

Appendix G. (cont.)

	Station F3		Station G1		Station H2		Station I3	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/L)								
Aluminum	1472	< 10-6880	1555	< 10-7680	1488	85-5980	1401	184-5070
Antimony	< 0.50	N/A	< 0.50	N/A	< 0.50	N/A	< 0.50	N/A
Arsenic	<0.50	<0.50-1.20	<0.50	<0.50-1.40	<0.50	<0.50-1.20	<0.50	<0.50-1.00
Barium	30	<0.10-75	29	<0.10-78	35	23-70	38	30-54
Beryllium	<0.20	<0.20-0.40	<0.20	<0.20-0.40	<0.20	<0.20-0.30	<0.20	<0.20-0.10
Boron	141.2[ab]	<50.0-318.0	75.5[bc]	<50.0-204.0	56.6[bc]	<50.0-111.0	<50.0	<50.0-59.0
Cadmium	< 0.080	N/A	< 0.080	N/A	< 0.080	N/A	< 0.080	N/A
Chromium	2.61[ab]	<0.50-11.10	2.78[ab]	<0.50-12.50	2.40[b]	<0.50-9.40	2.44[b]	0.70-7.60
Cobalt	0.88[b]	<0.50-3.80	0.90[b]	<0.50-4.10	0.78[b]	<0.50-3.20	0.80[b]	<0.50-2.00
Copper	1.7	<1.0-6.8	1.6	<1.0-7.5	1.8	<1.0-6.1	1.6	0.8-5.2
Iron	2288	516-8610	2308	<50-9660	2715	755-8070	2525	1170-6120
Lead	1.29	<0.10-5.30	1.32	<0.10-5.80	1.39	0.20-4.80	1.29	0.60-3.50
Manganese	63	25-174	60	<5.0-185	92	46-207	151	47-352
Mercury[3]	<0.20	N/A	0.0074[b]	0.0014-0.0227	<0.20	N/A	<0.20	N/A
Nickel	1.17[ab]	<0.50-4.50	1.24[ab]	<0.50-4.90	1.05[b]	<0.50-3.80	1.08[b]	<0.50-3.00
Selenium	<0.50	<0.50-0.50	<0.50	N/A	<0.50	<0.50-0.60	<0.50	N/A
Silver	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A
Thallium	<0.10	N/A	<0.10	<0.10-0.11	<0.10	N/A	<0.10	N/A
Vanadium	4.8	<0.3-19.1	5.0	<0.3-21.4	5.0	1.1-17.4	5.2	1.8-14.7
Zinc	5.3[b]	<5.0-19.4	5.6[b]	<5.0-20.8	<5.0	<5.0-15.9	<5.0	<5.0-10.6

[1]Unless otherwise noted, all measurements were taken from near-bottom. Appropriate statistical testing (parametric or non-parametric) was based on dataset distributions (normality testing). Mean separations testing was applied only if the overall model test statistical for the treatment was significant. Means followed by different superscripts were significantly different from each other (P = 0.05). The portions of rows where significant differences were applicable are shaded. Data were rounded to conform to significant digit requirements. Rounding may obscure some mean differences. Sample size equaled 6 unless otherwise noted. Statistical testing was conducted on near bottom water means only. N/A means not applicable and NS means not sampled.

[2]Less than values (<) indicate the Lower Reporting Limit (LRL) for the variable. The LRL is a statistically determined limit beyond which chemical concentrations cannot be reliably quantified. Statistical analyses were utilized only when mean concentrations were above the highest analytical LRL and where LRL values occurred, the means were calculated by utilizing one half of the absolute value of each LRL.

[3]Mercury was measured in micrograms per liter (µg/L) by USEPA Method 245.1 except at Station B1 and G1 where mercury was analyzed by USEPA Method 1631E and reported in micrograms per liter (µg/L).

Appendix H. **Means and ranges of aqueous trace element concentrations (µg/L) at sampling stations relative to aquatic life and human health screening values during 2016.**

			Element							
			Aluminum		Cobalt		Copper		Lead	
Screening Value			87.00/8,000.00		NA/4.00		7.00/NA		25/NA	
Matrix	n	Transect	Mean	Mean	Mean	Range	Mean	Range	Mean	Range
WATER	6	A	2,592	2.15	2.15	< 0.50-9.50	2.6	< 1.0-13.3	3,547	239-19,300
	6	B	3,971	3.10	3.10	< 0.50-12.40	3.8	< 1.0-19.7	5,399	415-28,600
	6	C	1,354	1.20	1.20	< 0.50-4.00	2.0	0.8-7.0	2,324	651-9,590
	6	D	1,341	1.15	1.15	< 0.50-3.90	1.9	0.5-6.9	1,415	609-4,420
	6	E	7,361	6.24	6.24	< 0.50-34.20	7.5	< 1.0-43	6,956	< 50-39,400
	6	F	1,472	1.29	1.29	< 0.50-3.80	1.7	< 1.0-6.8	2,288	516-8,610
	6	G	1,555	1.32	1.32	< 0.50-4.10	1.6	< 1.0-7.5	2,308	< 50-9,660
	6	H	1,488	1.39	1.39	< 0.50-3.20	1.8	< 1.0-6.1	2,715	755-8,070
	6	I	1,401	1.29	1.29	< 0.50-2.00	1.6	0.8-5.2	2,525	1,170-6,120

Appendix H. (cont.)

			Element					
			Mercury		Thallium		Thallium	
Screening Value			0.012/NA		0.47		0.47	
Matrix	n	Transect	Mean	Range	Mean	Range	Mean	Range
WATER	6	A	Mercury	NA	< 0.10	< 0.10-0.24	< 0.10	< 0.10-0.24
	6	B	0.012/NA	0.0009-0.0730	< 0.10	< 0.10-0.35	< 0.10	< 0.10-0.35
	6	C	Mean	NA	< 0.10	NA	< 0.10	NA
	6	D	< 0.20	NA	< 0.10	NA	< 0.10	NA
	6	E	0.0135	NA	0.20	< 0.10-0.67	0.20	< 0.10-0.67
	6	F	< 0.20	NA	< 0.10	NA	< 0.10	NA
	6	G	< 0.20	0.0014-0.0227	< 0.10	0.05-0.11	< 0.10	0.05-0.11
	6	H	< 0.20	NA	< 0.10	NA	< 0.10	NA
	6	I	< 0.20	NA	< 0.10	NA	< 0.10	NA

Units: µg/L
*Screening Values: Aquatic Life/Human Health
Note: Items **HIGHLIGHTED** indicate at least one or more water samples contained readings above screening values. Both the States of North Carolina and Virginia have eliminated iron from the Aquatic Life and Human Health water quality criteria/standards.

Appendix I. **Number of exceedances by station of either aquatic life or human health screening values from water samples collected in 2016.**

ALUMINUM	Transect A (NC)	Transect B (NC)	Transect C (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)	Transect I (VA)
Number of Samples > Screening Value	5/6	6/6	4/6	4/6	4/6	5/6	5/6	5/6	6/6

COBALT	Transect A (NC)	Transect B (NC)	Transect (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)	Transect I (VA)
Number of Samples > Screening Value	1/6	1/6	1/6	0/6	1/6	0/6	1/6	0/6	0/6

COPPER	Transect A (NC)	Transect B (NC)	Transect C (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)	Transect I (VA)
Number of Samples > Screening Value	1/6	1/6	1/6	0/6	1/6	0/6	1/6	0/6	1/6

LEAD	Transect A (NC)	Transect B (NC)	Transect C (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)	Transect I (VA)
Number of Samples > Screening Value	0/6	0/6	0/6	0/6	1/6	0/6	0/6	0/6	0/6

MERCURY	Transect A (NC)	Transect B (NC)	Transect C (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)	Transect I (VA)
Number of Samples > Screening Value	0/6	1/6	0/6	0/6	0/6	0/6	2/6	0/6	0/6

Appendix I. (cont.)

THALLIUM	Transect A (NC)	Transect B (NC)	Transect C (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)	Transect I (VA)
Number of Samples > Screening Value	0/6	0/6	0/6	0/6	1/6	0/6	0/6	0/6	0/6

ZINC	Transect A (NC)	Transect B (NC)	Transect C (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)	Transect I (VA)
Number of Samples > Screening Value	0/6	1/6	0/6	0/6	1/6	0/6	0/6	0/6	0/6

Appendix J. Spatial trends of means and ranges for trace element variables from near bottom waters of Dan River during 2017.[1,2]

	Station A1		Station B1		Station C3		Station D3		Station E1	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/L)										
Aluminum	229	39-531	320	80-1080	282	83-842	243	82-800	283	110-864
Antimony	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	<0.50-1.50
Arsenic	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A
Barium	18[b]	14-20	25[ab]	18-33	21[ab]	16-28	21[ab]	18-27	22[ab]	16-31
Beryllium	<0.20	<0.20-0.12	<0.20	N/A	<0.20	N/A	<0.20	N/A	<0.20	N/A
Boron	<50	N/A	190[a]	<50-386	81[ab]	<50-155	88[ab]	<50-160	100[ab]	<50-151
Cadmium	<0.080	N/A	<0.080	N/A	<0.080	N/A	<0.080	N/A	<0.080	N/A
Chromium	0.53	<0.50-1.30	0.81	<0.50-2.10	0.73	<0.50-1.80	0.73	<0.50-1.90	1.53	<0.50-5.00
Cobalt	<0.50	N/A	<0.50	<0.50-0.86	<0.50	<0.50-0.81	<0.50	<0.50-0.75	<0.50	<0.50-0.82
Copper	<1.0	N/A	<1.0	N/A	1.2	<1.0-2.1	1.2	<1.0-1.8	1.2	<1.0-2.2
Iron	477	201-914	898	323-2430	673	25-1690	656	25-1750	719	71-1820
Lead	<0.50	<0.50-0.54	<0.50	<0.50-1.30	<0.50	<0.50-1.00	<0.50	<0.50-0.93	<0.50	<0.50-1.10
Manganese	18[b]	89-29	49[ab]	29-69	45[ab]	26-77	48[ab]	31-76	42[ab]	23-75
Mercury[3]	<0.20	N/A	0.0017	0.0012-0.0023	<0.20	N/A	<0.20	N/A	<0.20	N/A
Nickel	<0.50	<0.50-0.66	<0.50	N/A	0.60	<0.50-1.10	<0.50	<0.50-0.97	0.87	<0.50-2.70
Selenium	<0.50	N/A	<0.50	<0.50-0.60	<0.50	N/A	<0.50	N/A	<0.50	N/A
Silver	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A
Thallium	<0.10	N/A	<0.10	N/A	<0.10	N/A	<0.10	N/A	<0.10	N/A
Vanadium	1.0[ab]	<1.0-1.8	<1.0	N/A	1.7[a]	<1.0-3.9	1.6[ab]	<1.0-3.6	1.7[ab]	<1.0-3.8
Zinc	<5.0	N/A	<5.0	N/A	<5.0	N/A	<5.0	N/A	<5.0	N/A

Appendix J. (cont.)

	Station F3		Station G1		Station H2		Station I3	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/L)								
Aluminum	280	75-852	282	92-781	1472	202-6270	716	517-883
Antimony	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A
Arsenic	<0.50	N/A	<0.50	N/A	<0.50	<0.50-1.20	<0.50	<0.50-0.50
Barium	21[ab]	16-30	22[ab]	16-29	38[ab]	19-87	33[a]	26-41
Beryllium	<0.20	N/A	<0.20	N/A	<0.20	<0.20-0.41	<0.20	N/A
Boron	77[ab]	<50-122	74[ab]	<50-137	<50	<50-88	<50	<50-70
Cadmium	<0.080	N/A	<0.080	N/A	<0.080	N/A	<0.080	N/A
Chromium	0.68	<0.50-1.80	2.90	<0.50-14.00	2.89	<0.50-11.40	1.73	1.10-2.10
Cobalt	<0.50	<0.50-0.76	<0.50	<0.50-0.69	1.23	<0.50-4.80	0.62	<0.50-0.71
Copper	<1.0	<1.0-2.0	1.0	<1.0-1.6	2.6	<1.0-9.3	1.5	1.1-2.1
Iron	599	87-1540	670	25-1700	2960	50-12,000	1413	57-2050
Lead	<0.50	<0.50-0.99	<0.50	<0.50-0.96	1.76	<0.50-6.90	0.82	0.72-0.96
Manganese	35[ab]	20-70	40[ab]	24-61	127[a]	39-394	81[a]	45-146
Mercury[3]	<0.20	N/A	0.0016	0.0012-0.0021	<0.20	N/A	<0.20	N/A
Nickel	<0.50	<0.50-0.94	0.57	<0.50-1.60	1.44	<0.50-5.00	1.00	0.60-1.10
Selenium	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A
Silver	<0.50	N/A	<0.50	N/A	<0.50	N/A	<0.50	N/A
Thallium	<0.10	N/A	<0.10	N/A	<0.10	N/A	<0.10	N/A
Vanadium	1.6[ab]	<1.0-3.7	1.7[ab]	<1.0-3.4	6.2[a]	1.2-22.60	3.4[a]	2.6-4.2
Zinc	<5.0	<5.0-6.90	<5.0	N/A	6.52	<5.0-22.70	<5.0	N/A

[1]Unless otherwise noted, all measurements were taken from near-bottom. Appropriate statistical testing (parametric or non-parametric) was based on dataset distributions (normality testing). Mean separations testing was applied only if the overall model test statistical for the treatment was significant. Means followed by different superscripts were significantly different from each other (P = 0.05). The portions of rows where significant differences were applicable are shaded. Data were rounded to conform to significant digit requirements. Rounding may obscure some mean differences. Sample size equaled 6 unless otherwise noted. Statistical testing was conducted on near bottom water means only. N/A means not applicable and NS means not sampled.

[2]Less than values (<) indicate the Lower Reporting Limit (LRL) for the variable. The LRL is a statistically determined limit beyond which chemical concentrations cannot be reliably quantified. Statistical analyses were utilized only when mean concentrations were above the highest analytical LRL and where LRL values occurred, the means were calculated by utilizing one half of the absolute value of each LRL.

[3]Mercury was measured in micrograms per liter (µg/L) by USEPA Method 245.1 except at Station B1 and G1 where mercury was analyzed by USEPA Method 1631E and reported in micrograms per liter (µg/L)

Appendix K. Means and ranges of aqueous trace element concentrations (µg/L) at sampling Stations relative to aquatic life and human health screening values during 2017.

			Element					
			Aluminum		Cobalt		Copper	
Screening Value			87.00/8,000.00		NA/4.00		7.00/NA	
Matrix	n	Transect	Mean	Range	Mean	Range	Mean	Range
WATER	6	A	229	39-531	< 0.50	NA	< 1.0	NA
	6	B	320	80-1,080	< 0.50	< 0.50-0.86	< 1.0	NA
	6	C	282	83-842	< 0.50	< 0.50-0.81	1.2	< 1.0-2.1
	6	D	243	82-800	< 0.50	< 0.50-0.75	1.2	< 1.0-1.8
	6	E	283	110-864	< 0.50	< 0.50-0.82	1.0	< 1.0-2.2
	6	F	280	75-852	0.28	< 0.50-0.76	< 1.0	< 1.0-2.0
	6	G	282	92-781	0.29	< 0.50-0.69	1.0	< 1.0-1.6
	6	H	1,472	202-6,270	1.23	< 0.50-4.80	2.6	< 1.0-9.3
	6	I	716	517-883	0.62	< 0.50-0.71	1.5	< 1.0-2.1

Units: µg/L
*Screening Values: Aquatic Life/Human Health
Note: Items **HIGHLIGHTED** indicate at least one or more water samples contained readings above screening values. Both the States of North Carolina and Virginia have eliminated iron from the Aquatic Life and Human Health water quality criteria/standards.

.

Appendix L. Number of exceedances by station of either aquatic life or human health screening values from water samples collected in 2017.

ALUMINUM	Transect A (NC)	Transect B (NC)	Transect C (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)	Transect I (VA)
Number of Samples > Screening Value	5/6	6/6	4/6	4/6	4/6	5/6	5/6	5/6	6/6

COBALT	Transect A (NC)	Transect B (NC)	Transect C (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)	Transect I (VA)
Number of Samples > Screening Value	0/6	0/6	0/6	0/6	0/6	0/6	0/6	1/6	0/6

COPPER	Transect A (NC)	Transect B (NC)	Transect C (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)	Transect I (VA)
Number of Samples > Screening Value	0/6	0/6	0/6	0/6	0/6	0/6	0/6	1/6	0/6

Appendix M. Trace element mean and range concentrations in µg/g wet weight from sediments across sampling sites that some or all of the values exceeded ecological screening values during 2015.[1]

			Element					
			Aluminum		**Barium**		**Manganese**	
Screening Value			3,200 µg/g		60 µg/g		460 µg/g	
Matrix	n	Transect	Mean	Range	Mean	Range	**Mean**	**Range**
SEDIMENTS	3	B	11,125	9,885-13,499	66	62-73	289	276-299
	3	C	9,085	7,751-10,355	66	61-70	291	252-315
	3	E	14,345	10,592-16,584	108	102-111	384	373-395
	3	F	7,125	5,845-7,797	55	47-60	196	162-214
	3	G	11,188	10,049-12,226	82	76-91	310	291-322
	3	H	11,140	8,908-13,303	84	69-100	465	377-553

[1]Units: µg/g. Note: Items **HIGHLIGHTED** indicate at least one sediment sample contained readings above screening value

Appendix N. Trace elements observed above screening values and exceedances by element for sediment samples collected in 2015.

ALUMINUM	Transect B (NC)	Transect C (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)
Number of Samples > Screening Value	3/3	3/3	3/3	3/3	3/3	3/3

BARIUM	Transect B (NC)	Transect C (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)
Number of Samples > Screening Value	3/3	3/3	3/3	1/3	3/3	3/3

Appendix O. Trace element mean and range concentrations in µg/g wet weight from sediments across sampling sites that some or all of the values exceeded ecological screening values during 2016.[1]

			Element							
			Aluminum		**Barium**		**Manganese**		**Selenium**	
Screening Value			3,200 µg/g		60 µg/g		460 µg/g		2 µg/g	
Matrix	n	Transect	Mean	Range	Mean	Range	Mean	Range	Mean	Range
SEDIMENTS	3	B	8,524	6,441-12,121	64	55-82	242	198-324	1.42	1.03-1.97
	3	C	10,782	9,120-11,899	74	68-78	296	263-327	1.88	1.68-2.06
	3	E	6,965	6,221-7,744	48	44-50	195	174-207	1.14	1.06-1.19
	3	F	14,102	11,541-15,431	105	88-118	468	366-546	2.37	1.97-2.57
	3	G	9,730	9,410-10,140	73	67-83	335	330-338	1.64	1.46-1.83
	3	H	8,528	7,104-11,143	68	56-88	337	270-458	1.24	0.98-1.67

[1]Units: µg/g. Items **HIGHLIGHTED** indicate at least one sediment sample contained readings above screening value

Appendix P. Trace elements observed above screening values by element for sediment samples collected in 2016.

ALUMINUM	Transect B (NC)	Transect C (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)
Number of Samples > Screening Value	3/3	3/3	3/3	3/3	3/3	3/3
BARIUM	Transect B (NC)	Transect C (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)
Number of Samples > Screening Value	1/3	3/3	0/3	3/3	3/3	1/3
MANGANESE	Transect B (NC)	Transect C (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)
Number of Samples > Screening Value	0/3	0/3	0/3	2/3	0/3	0/3
SELENIUM	Transect B (NC)	Transect C (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)
Number of Samples > Screening Value	0/3	1/3	0/3	1/3	0/3	0/3

Appendix Q. Trace element mean and range concentrations in µg/g wet weight from sediments across sampling sites that some or all of the values exceeded ecological screening values during 2017.[1]

			Element					
			Aluminum		**Barium**		**Manganese**	
Screening Value			3,200 µg/g		60 µg/g		460 µg/g	
Matrix	n	Transect	Mean	Range	Mean	Range	Mean	Range
SEDIMENTS	3	B	12,413	6,312-17,210	85	44-117	363	188-502
	3	C	6,542	5,424-8,280	57	48-74	164	133-216
	3	E	9,242	7,308-11,906	74	59-91	238	192-298
	3	F	6,738	5,980-7,487	56	50-62	203	178-219
	3	G	7,353	6,795-7,956	59	55-62	199	182-212
	3	H	8,262	6,084-10,468	65	49-83	278	194-364

[1]Units: µg/g. Note: Items **HIGHLIGHTED** indicate at least one sediment sample contained readings above screening value

Appendix R. Trace elements observed above screening values by element for sediment samples collected in 2017.

ALUMINUM	Transect B (NC)	Transect C (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)
Number of Samples > Screening Value	3/3	3/3	3/3	3/3	3/3	3/3
BARIUM	Transect B (NC)	Transect C (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)
Number of Samples > Screening Value	2/3	1/3	2/3	1/3	2/3	2/3
MANGANESE	Transect B (NC)	Transect C (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect H (VA)
Number of Samples > Screening Value	1/3	0/3	0/3	0/3	0/3	0/3

Appendix S. Spatial trends of means and ranges for trace element variables from periphyton in the Dan River during 2015.[1]

	Station B		Station C		Station E	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	4059	3966-4123	557	536-571	3072	3045-3105
Antimony	0.013	0.009-0.022	0.011	0.010-0.012	0.011	0.010-0.012
Arsenic	0.89	0.88-0.89	0.14	0.13-0.14	0.75	0.74-0.75
Barium	34	33-35	7.55	7.34-7.67	25	24-26
Beryllium	0.16	0.16-0.17	0.02	N/A	0.12	0.12-0.13
Boron	1.08	0.99-1.29	0.62	0.59-0.63	0.53	0.50-0.57
Cadmium	0.024	0.014-0.037	0.0032	0.0029-0.0033	0.0121	0.0121-0.0121
Chromium	5.37	5.13-5.96	0.72	0.70-0.74	4.23	4.13-4.34
Cobalt	2.16	2.10-2.19	0.38	0.37-0.39	1.93	1.86-2.00
Copper	3.76	3.65-3.84	0.59	0.57-0.60	3.51	3.51-3.53
Iron	5005	4594-5392	647	628-658	3879	3759-4010
Lead	2.73	2.72-2.77	0.37	0.36-0.37	2.33	2.25-2.42
Manganese	372	352-393	122	119-124	355	342-372
Mercury	0.006	N/A	0.007	N/A	0.006	0.006-0.008
Nickel	2.63	2.60-2.68	0.41	0.40-0.42	2.21	2.16-2.26
Selenium	0.72	0.66-0.78	0.10	0.09-0.10	0.56	0.55-0.57
Silver	0.005	0.003-0.010	0.006	0.006-0.007	0.006	0.004-0.008
Thallium	0.061	0.057-0.073	0.009	0.008-0.009	0.042	0.040-0.042
Vanadium	8.70	8.44-9.26	1.15	1.11-1.17	7.06	6.89-7.29
Zinc	11	N/A	1.72	1.66-1.78	11	10-11

Appendix S. (cont.)

	Station F		Station G		Station H	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	81	79-84	1717	1589-1797	368	355-380
Antimony	0.001	N/A	0.007	0.007-0.008	0.003	0.003-0.004
Arsenic	0.03	N/A	0.51	0.49-0.52	0.12	0.12-0.13
Barium	3.49	3.44-3.53	15	N/A	8.59	8.14-9.02
Beryllium	0.003	N/A	0.07	0.07-0.08	0.01	0.01-0.02
Boron	0.19	N/A	0.27	0.24-0.30	0.17	0.16-0.18
Cadmium	0.001	N/A	0.007	0.007-0.008	0.002	N/A
Chromium	0.10	N/A	2.40	2.34-2.44	0.55	0.53-0.57
Cobalt	0.14	N/A	1.32	1.31-1.33	0.40	0.38-0.44
Copper	0.12	N/A	1.92	1.91-1.93	0.41	0.38-0.43
Iron	101	99-103	2598	2553-2662	988	908-1156
Lead	0.05	N/A	1.34	N/A	0.27	0.26-0.28
Manganese	118	117-120	397	392-102	178	167-188
Mercury	< 0.001	N/A	0.003	N/A	0.001	N/A
Nickel	0.09	0.09-0.10	1.23	1.16-1.31	0.30	0.29-0.32
Selenium	0.02	N/A	0.25	0.24-0.27	0.07	N/A
Silver	0.0001	N/A	0.002	0.001-0.002	0.0004	N/A
Thallium	0.002	N/A	0.024	N/A	0.005	N/A
Vanadium	0.20	N/A	3.87	3.82-3.92	0.92	0.89-0.94
Zinc	0.39	0.39-0.40	5.09	5.05-5.12	1.22	1.17-1.26

[1] Note: no ecological screening values are available for periphyton for comparison purposes.

Appendix T. Spatial trends of means and ranges for trace element variables from periphyton in the Dan River during 2016. [1]

	Station B		Station C		Station E	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	3103	3056-3164	1311	1293-1327	3315	3134-3427
Antimony	0.008	0.007-0.008	0.005	N/A	0.009	0.008-0.009
Arsenic	0.52	0.51-0.53	0.21	0.21-0.22	0.48	0.48-0.49
Barium	18	18-19	11	N/A	23	N/A
Beryllium	0.12	0.12-0.13	0.05	N/A	0.13	N/A
Boron	0.83	0.81-0.87	0.19	0.18-0.19	0.34	0.34-0.35
Cadmium	0.013	0.011-0.015	0.006	0.006-0.007	0.015	0.013-0.0.16
Chromium	3.77	3.74-3.79	1.51	1.51-1.52	3.97	3.94-4.00
Cobalt	1.57	1.56-1.58	0.74	0.74-0.75	1.87	1.85-1.89
Copper	2.45	2.43-2.46	1.11	1.10-1.12	2.75	2.74-2.77
Iron	3412	3387-3437	1387	1366-1409	3639	3622-3648
Lead	1.70	1.69-1.72	0.67	0.66-0.67	1.80	1.78-1.81
Manganese	171	171-173	139	138-141	288	285-290
Mercury[3]	0.004	N/A	0.001	0.001-0.002	0.004	N/A
Nickel	1.91	1.89-1.94	0.87	0.86-0.88	2.12	2.07-2.15
Selenium	0.41	0.40-0.42	0.18	0.17-0.18	0.43	0.42-0.45
Silver	0.002	N/A	0.001	N/A	0.002	0.002-0.003
Thallium	0.026	0.023-0.029	0.006	0.006-0.007	0.020	0.019-0.020
Vanadium	6.05	6.01-6.08	2.53	2.52-2.53	6.66	6.63-6.69
Zinc	7.52	7.44-7.59	3.35	3.31-3.41	8.40	8.35-8.48

Appendix T. (cont.)

	Station F		Station G		Station H	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	3861	3677-4137	5179	5005-5335	628	602-664
Antimony	0.010	0.008-0.014	0.010	0.009-0.012	0.003	0.002-0.003
Arsenic	0.94	0.74-1.32	0.93	0.86-0.99	0.15	0.14-0.16
Barium	32	30-35	26	26-27	7.33	7.15-7.48
Beryllium	0.14	0.13-0.15	0.23	0.19-0.29	0.03	0.02-0.03
Boron	1.53	1.12-1.98	1.05	0.42-1.68	0.37	0.34-0.40
Cadmium	0.120	0.014-0.331	0.092	0.032-0.128	0.008	0.008-0.009
Chromium	4.52	4.37-4.74	5.90	5.71-6.04	0.81	0.80-0.82
Cobalt	2.17	2.04-2.32	2.43	2.32-2.49	0.40	0.39-0.40
Copper	3.11	2.96-3.29	3.82	3.64-4.01	0.50	N/A
Iron	4100	3935-4321	5179	5005-5324	741	740-742
Lead	1.98	1.95-2.02	2.61	2.57-2.65	0.36	0.35-0.37
Manganese	463	401-535	267	253-279	136	134-138
Mercury	0.008	0.003-0.016	0.006	N/A	0.008	N/A
Nickel	2.43	2.32-2.57	2.98	2.86-3.09	0.42	0.42-0.43
Selenium	0.78	0.59-1.18	0.97	0.95-0.99	0.11	0.10-0.12
Silver	0.036	0.002-0.103	0.032	0.006-0.045	0.002	N/A
Thallium	0.032	0.024-0.048	0.055	0.053-0.058	0.008	0.008-0.009
Vanadium	7.62	7.28-7.98	9.38	9.06-9.59	1.25	1.23-1.28
Zinc	9.81	9.45-10	12	11-12	1.58	1.56-1.61

[1]Note: no ecological screening values are available for periphyton for comparison purposes.

Appendix U. Spatial trends of means and ranges for trace element variables from periphyton in the Dan River during 2017.[1]

	Station B		Station C		Station E	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	382	374-389	55	46-59	374	363-388
Antimony	0.0043	0.0035-0.0056	0.0013	0.0010-0.0015	0.0043	0.0042-0.0043
Arsenic	0.68	0.67-0.69	0.53	0.51-0.54	0.48	0.47-0.48
Barium	4.76	4.71-4.79	2.14	2.08-2.21	5.19	5.10-5.31
Beryllium	0.018	0.017-0.020	0.003	0.003-0.004	0.017	0.016-0.018
Boron	0.17	0.16-0.17	0.08	0.07-0.08	0.12	0.11-0.13
Cadmium	0.11	0.10-0.12	0.06	0.06-0.07	0.07	0.06-0.07
Chromium	0.71	0.70-0.72	0.44	0.35-0.48	0.86	0.82-0.88
Cobalt	0.34	0.33-0.34	0.59	0.55-0.62	0.46	0.46-0.47
Copper	4.91	4.83-4.95	5.09	4.82-5.30	5.01	4.93-5.11
Iron	505	478-548	90	86-93	500	493-505
Lead	0.30	0.29-0.31	0.06	0.05-0.06	0.28	0.28-0.29
Manganese	16	N/A	4.97	4.80-5.08	26	N/A
Mercury	0.019	0.018-0.020	0.012	0.009-0.014	0.012	0.012-0.013
Nickel	0.31	0.28-0.36	0.15	0.09-0.18	0.44	0.39-0.49
Selenium	0.74	0.70-0.77	0.48	0.47-0.48	0.55	0.54-0.56
Silver	0.012	0.009-0.017	0.009	0.008-0.010	0.011	0.008-0.015
Thallium	0.017	0.016-0.018	0.005	0.004-0.005	0.011	N/A
Vanadium	0.89	0.86-0.92	0.14	0.11-0.16	0.90	0.88-0.92
Zinc	24	N/A	18	17-18	26	26-27

Appendix U. (cont.)

	Station F		Station G		Station H	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	110	106-112	133	129-136	317	302-325
Antimony	0.0023	0.0022-0.0024	0.0034	0.0024-0.0054	0.0057	0.0048-0.0071
Arsenic	0.49	0.48-0.50	0.40	0.38-0.42	0.35	0.34-0.35
Barium	3.25	3.24-3.27	6.95	6.89-7.00	4.31	4.22-4.40
Beryllium	0.006	0.005-0.006	0.008	0.007-0.008	0.015	0.014-0.016
Boron	0.09	0.09-0.10	0.12	0.11-0.13	0.20	0.18-0.21
Cadmium	0.07	N/A	0.04	0.04-0.05	0.06	0.06-0.07
Chromium	2.39	1.53-3.01	0.38	0.32-0.44	0.96	0.88-1.18
Cobalt	0.35	0.34-0.36	0.39	0.38-0.40	0.36	0.34-0.37
Copper	5.08	4.99-5.16	6.33	6.06-6.48	11	N/A
Iron	198	186-206	254	247-261	413	402-419
Lead	0.11	0.10-0.11	0.14	0.14-0.15	0.27	0.26-0.28
Manganese	9.72	9.57-9.84	28	28-29	14	N/A
Mercury[3]	0.016	0.015-0.017	0.008	0.007-0.011	0.007	0.006-0.007
Nickel	1.58	0.95-2.06	0.40	0.24-0.66	0.47	0.40-0.64
Selenium	0.53	0.52-0.53	0.31	0.30-0.32	0.32	0.30-0.34
Silver	0.011	0.010-0.011	0.010	0.009-0.010	0.010	0.008-0.010
Thallium	0.008	N/A	0.005	0.004-0.007	0.007	0.006-0.008
Vanadium	0.43	0.37-0.46	0.35	0.35-0.36	0.81	0.78-0.84
Zinc	24	N/A	14	14-15	17	16-17

[1] Note: no ecological screening values are available for periphyton for comparison purposes.

Appendix V. Spatial trends of means and ranges for trace element variables from benthic macroinvertebrates in the Dan River during 2015. [1]

	Station B		Station C		Station E	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	970	923-1041	340	337-347	800	750-888
Antimony	0.006	0.005-0.007	0.018	0.017-0.018	0.009	0.008-0.010
Arsenic	0.33	0.31-0.37	0.17	0.16-0.17	0.36	0.34-0.39
Barium	6.99	6.73-7.40	14	13-14	6.59	6.54-6.69
Beryllium	0.044	0.041-0.044	0.015	0.014-0.015	0.036	0.032-0.042
Boron	0.75	0.67-0.90	1.01	0.99-1.02	0.30	0.29-0.31
Cadmium	0.02	0.01-0.02	0.05	0.05-0.06	0.02	0.02-0.03
Chromium	1.36	1.32-1.43	0.62	0.61-0.65	1.21	1.19-1.25
Cobalt	0.88	0.85-0.93	1.80	1.74-1.84	0.87	0.86-0.89
Copper	2.25	2.16-2.40	6.56	6.40-6.67	3.18 [b]	310-3.22
Iron	1420	1377-1497	482	473-494	1188	1139-1236
Lead	0.72	0.70-0.74	0.29	N/A	0.61	0.57-0.62
Manganese	38	36-41	752	722-776	79	64-97
Mercury[3]	0.004	0.004-0.005	0.012	0.012-0.013	0.005	0.005-0.006
Nickel	0.69	0.67-0.73	0.67	0.65-0.70	0.66	0.66-0.67
Selenium	0.55	0.50-0.65	0.53	0.51-0.56	0.54	0.52-0.57
Silver	0.002	0.001-0.002	0.010	0.009-0.011	0.005	0.004-0.005
Thallium	0.014	0.013-0.014	0.019	0.018-0.019	0.011	0.11-0.012
Vanadium	2.45	2.39-2.57	1.08	1.07-1.09	2.04 [b]	1.99-2.09
Zinc	22	22-23	34	34-35	22	21-22

Appendix V. (cont.)

	Station F		Station G		Station H	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	291	280-302	688	669-714	725	645-781
Antimony	0.011	0.010-0.012	0.011	N/A	0.011	0.010-0.013
Arsenic	0.23	0.22-0.24	0.51	0.51-0.53	0.29	0.24-0.31
Barium	10	10-11	5.68	5.58-5.81	6.17	5.36-6.61
Beryllium	0.0122	0.010-0.014	0.033	0.032-0.034	0.031	0.029-0.034
Boron	0.30	0.29-0.31	0.18	0.18-0.19	0.37	0.32-0.41
Cadmium	0.02	0.02-0.03	0.02	N/A	0.01	N/A
Chromium	0.36	0.35-0.37	0.92	0.90-0.94	1.12	1.01-1.19
Cobalt	1.09	1.06-1.12	0.56	0.54-0.56	0.48	0.42-0.51
Copper	4.67	4.61-4.76	2.32	2.29-2.35	1.87	1.67-1.97
Iron	388	384-392	1453	1416-1499	1115	977-1120
Lead	0.21	0.21-0.22	0.50	0.49-0.53	0.62	0.53-0.66
Manganese	375	366-390	44	43-45	33	30-35
Mercury[3]	0.012	0.012-0.013	0.005	0.004-0.005	0.003	N/A
Nickel	0.46	N/A	0.46	0.45-0.47	0.54	0.49-0.57
Selenium	0.60	0.57-0.62	0.75	0.71-0.79	0.39	0.35-0.42
Silver	0.009	0.009-0.010	0.002	0.001-0.003	0.003	0.003-0.004
Thallium	0.017	0.016-0.020	0.009	0.008-0.009	0.009	0.008-0.009
Vanadium	0.85	0.84-0.86	2.32	2.28-2.39	2.04	1.79-2.20
Zinc	30	29-31	39	38-39	15[f]	13-15

[1]Note: no ecological screening values are available for benthic macroinvertebrates for comparison purposes.

Appendix W. Spatial trends of means and ranges for trace element variables from benthic macroinvertebrates in the Dan River during 2016. [1]

	Station B		Station C		Station E	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	697	576-844	174	156-205	487	369-655
Antimony	0.006	0.004-0.008	0.002	0.002-0.003	0.005	NA
Arsenic	0.28	0.23-0.34	0.14	0.12-0.15	0.18	0.14-0.23
Barium	4.64	3.78-5.60	1.50	1.21-1.96	5.13	4.26-5.64
Beryllium	0.038	0.032-0.042	0.25	0.007-0.038	0.030	0.011-0.042
Boron	0.53	0.44-0.58	0.34	0.05-0.53	0.42	0.15-0.59
Cadmium	0.02	0.01-0.03	0.02	0.01-0.02	0.03	0.02-0.03
Chromium	4.23	2.17-7.44	1.49	1.22-1.93	5.64	4.28-7.54
Cobalt	1.33	1.00-1.69	0.54	0.46-0.64	1.63	0.88-2.13
Copper	19	10-33	6.51	5.76-7.68	22	21-26
Iron	994	754-1288	229	209-268	636	500-801
Lead	0.46	0.38-0.56	0.14	0.12-0.17	0.31	0.25-0.38
Manganese	36	24-52	24	12-41	137	55-194
Mercury[3]	0.007	0.006-0.008	0.008	0.006-0.009	0.008	0.007-0.009
Nickel	2.94	1.49-5.27	1.07	0.86-1.40	4.20	3.17-5.52
Selenium	0.65	0.56-0.76	0.44	0.39-0.54	0.41	0.39-0.50
Silver	0.005	0.003-0.009	0.004	0.003-0.005	0.006	0.005-0.009
Thallium	0.008	0.007-0.010	0.003	0.003-0.004	0.011	0.009-0.013
Vanadium	1.58	1.30-1.88	0.41	0.37-0.48	1.05	0.84-1.29
Zinc	20	17-23	18	17-21	20	19-22

Appendix W. (cont.)

	Station F		Station G		Station H	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/L)						
Aluminum	242	209-277	1020	996-1041	1118	897-1554
Antimony	0.016	0.008-0.029	0.008	0.008-0.009	0.009	0.007-0.012
Arsenic	0.22	0.20-0.23	0.28	0.27-0.28	0.33	0.29-0.40
Barium	1.92	1.69-2.24	6.01	5.94-6.13	6.50	5.29-8.77
Beryllium	0.038	0.013-0.081	0.046	0.042-0.049	0.044	0.032-0.064
Boron	0.28	0.20-0.37	0.24	0.23-0.25	0.27	0.25-0.29
Cadmium	0.03	0.02-0.04	0.02	0.01-0.03	0.02	N/A
Chromium	3.12	2.40-4.27	1.67	1.60-1.72	2.15	1.96-2.50
Cobalt	3.06	1.55-5.58	1.02	0.99-1.04	1.74	1.45-1.92
Copper	18	12-27	9.14	8.90-9.27	11	8.20-13
Iron	354	323-383	1446	1410-1468	1467	1203-1959
Lead	0.18	0.15-0.20	0.65	0.64-0.65	0.71	0.55-1.00
Manganese	24	15-33	26	25-26	36	33-41
Mercury[3]	0.010	0.009-0.010	0.006	N/A	0.006	0.004-0.008
Nickel	2.34	1.77-3.25	0.95	0.90-0.99	1.25	1.19-1.36
Selenium	0.42	0.36-0.50	0.39	0.38-0.40	0.53	0.52-0.54
Silver	0.012	0.010-0.018	0.004	0.001-0.008	0.004	0.003-0.004
Thallium	0.007	0.003-0.015	0.004	N/A	0.004	N/A
Vanadium	0.52	0.38-0.63	2.40	2.31-2.45	2.64	2.11-3.68
Zinc	20	20-21	16	16-17	18	17-19

[1]Note: no ecological screening values are available for benthic macroinvertebrates for comparison purposes.

Appendix X. Spatial trends of means and ranges for trace element variables from benthic macroinvertebrates in the Dan River during 2017. [1]

	Station B		Station C		Station E	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	651	587-722	173	161-197	894	816-1040
Antimony	0.008	0.008-0.009	0.004	N/A	0.006	N/A
Arsenic	0.25	0.22-0.30	0.16	0.15-0.17	0.24	0.18-0.30
Barium	4.25	3.86-4.61	3.92	3.38-4.91	6.18	5.83-6.48
Beryllium	0.029	0.027-0.031	0.012	0.011-0.012	0.036	0.031-0.043
Boron	0.20	0.18-0.22	0.15	0.14-0.17	0.32	0.19-0.51
Cadmium	0.042	0.035-0.047	0.032	0.032-0.033	0.032	0.022-0.045
Chromium	1.58	1.08-2.39	0.42	0.33-0.54	1.46	1.36-1.55
Cobalt	1.29	0.76-2.26	0.84	0.76-1.00	0.90	0.84-0.95
Copper	20	13-31	7.47	6.31-9.52	19	15-25
Iron	882	782-988	269	254-293	1179	1085-1328
Lead	0.47	0.42-0.52	0.15	0.14-0.17	0.58	0.54-0.63
Manganese	27	25-29	141	113-196	53	50-59
Mercury[3]	0.007	0.007-0.008	0.011	0.010-0.011	0.006	0.006-0.007
Nickel	0.94	0.59-1.51	0.38	0.30-0.49	0.83	0.78-0.86
Selenium	0.61	0.55-0.68	0.56	0.55-0.58	0.42	0.33-0.53
Silver	0.012	0.011-0.013	0.007	0.007-0.008	0.016	0.011-0.023
Thallium	0.009	0.008-0.009	0.007	0.007-0.008	0.010	0.009-0.011
Vanadium	1.65	1.49-1.83	0.55	0.51-0.60	2.10	1.94-2.40
Zinc	20	18-21	22	21-23	21	19-24

Appendix X. (cont.)

	Station F		Station G		Station H	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	205	172-225	435	328-562	1227	1208-1251
Antimony	0.006	0.005-0.007	0.004	0.003-0.006	0.014	N/A
Arsenic	0.14	0.12-0.17	0.13	0.09-0.17	0.28	0.26-0.31
Barium	7.41	6.64-8.87	3.20	2.31-4.51	8.31	8.22-8.45
Beryllium	0.050	0.025-0.065	0.018	0.013-0.023	0.052	N/A
Boron	1.19	0.31-2.68	0.17	0.11-0.23	0.22	0.22-0.23
Cadmium	0.026	0.023-0.028	0.012	0.006-0.020	0.023	0.020-0.026
Chromium	0.59	0.42-0.84	0.69	0.52-0.89	1.93	1.90-1.97
Cobalt	0.95	0.86-1.04	0.44	0.29-0.68	0.84	N/A
Copper	11	9.93-12	15	9.74-26	23	N/A
Iron	315	270-353	615	465-768	1619	1598-1636
Lead	0.15	0.13-0.17	0.32	0.25-0.41	0.94	0.93-0.96
Manganese	263	225-328	30	16-57	53	53-54
Mercury[3]	0.020	0.018-0.023	0.004	0.003-0.008	0.007	N/A
Nickel	0.68	0.47-1.01	0.40	0.29-0.55	0.96	0.95-0.98
Selenium	0.50	0.47-0.55	0.24	0.16-0.39	0.44	0.40-0.47
Silver	0.027	0.014-0.036	0.009	0.004-0.012	0.036	0.023-0.045
Thallium	0.014	0.012-0.017	0.005	0.004-0.007	0.012	0.012-0.013
Vanadium	0.60	0.53-0.67	1.12	0.85-1.41	3.07	3.04-3.12
Zinc	25	20-31	11	7.33-16	18	N/A

[1]Note: no ecological screening values are available for benthic macroinvertebrates for comparison purposes.

Appendix Y. Spatial trends of means and ranges for trace element variables from *Corbicula fluminea* in the Dan River during 2015.[1]

	Station B		Station C		Station E	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	382	374-389	55	46-59	374	363-388
Antimony	0.0043	0.0035-0.0056	0.0013	0.0010-0.0015	0.0043	0.0042-0.0043
Arsenic	0.68	0.67-0.69	0.53	0.51-0.54	0.48	0.47-0.48
Barium	4.76	4.71-4.79	2.14	2.08-2.21	5.19	5.10-5.31
Beryllium	0.018	0.017-0.020	0.003	0.003-0.004	0.017	0.016-0.018
Boron	0.17	0.16-0.17	0.08	0.07-0.08	0.12	0.11-0.13
Cadmium	0.11	0.10-0.12	0.06	0.06-0.07	0.07	0.06-0.07
Chromium	0.71	0.70-0.72	0.44	0.35-0.48	0.86	0.82-0.88
Cobalt	0.34	0.33-0.34	0.59	0.55-0.62	0.46	0.46-0.47
Copper	4.91	4.83-4.95	5.09	4.82-5.30	5.01	4.93-5.11
Iron	505	478-548	90	86-93	500	493-505
Lead	0.30	0.29-0.31	0.06	0.05-0.06	0.28	0.28-0.29
Manganese	16	N/A	4.97	4.80-5.08	26	N/A
Mercury[3]	0.019	0.018-0.020	0.012	0.009-0.014	0.012	0.012-0.013
Nickel	0.31	0.28-0.36	0.15	0.09-0.18	0.44	0.39-0.49
Selenium	0.74	0.70-0.77	0.48	0.47-0.48	0.55	0.54-0.56
Silver	0.012	0.009-0.017	0.009	0.008-0.010	0.011	0.008-0.015
Thallium	0.017	0.016-0.018	0.005	0.004-0.005	0.011	N/A
Vanadium	0.89	0.86-0.92	0.14	0.11-0.16	0.90	0.88-0.92
Zinc	24	N/A	18	17-18	26	26-27

Appendix Y. (cont.)

	Station F		Station G		Station H	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	110	106-112	133	129-136	317	302-325
Antimony	0.0023	0.0022-0.0024	0.0034	0.0024-0.0054	0.0057	0.0048-0.0071
Arsenic	0.49	0.48-0.50	0.40	0.38-0.42	0.35	0.34-0.35
Barium	3.25	3.24-3.27	6.95	6.89-7.00	4.31	4.22-4.40
Beryllium	0.006	0.005-0.006	0.008	0.007-0.008	0.015	0.014-0.016
Boron	0.09	0.09-0.10	0.12	0.11-0.13	0.20	0.18-0.21
Cadmium	0.07	N/A	0.04	0.04-0.05	0.06	0.06-0.07
Chromium	2.39	1.53-3.01	0.38	0.32-0.44	0.96	0.88-1.18
Cobalt	0.35	0.34-0.36	0.39	0.38-0.40	0.36	0.34-0.37
Copper	5.08	4.99-5.16	6.33	6.06-6.48	11	N/A
Iron	198	186-206	254	247-261	413	402-419
Lead	0.11	0.10-0.11	0.14	0.14-0.15	0.27	0.26-0.28
Manganese	9.72	9.57-9.84	28	28-29	14	N/A
Mercury[3]	0.016	0.015-0.017	0.008	0.007-0.011	0.007	0.006-0.007
Nickel	1.58	0.95-2.06	0.40	0.24-0.66	0.47	0.40-0.64
Selenium	0.53	0.52-0.53	0.31	0.30-0.32	0.32	0.30-0.34
Silver	0.011	0.010-0.011	0.010	0.009-0.010	0.010	0.008-0.010
Thallium	0.008	N/A	0.005	0.004-0.007	0.007	0.006-0.008
Vanadium	0.43	0.37-0.46	0.35	0.35-0.36	0.81	0.78-0.84
Zinc	24	N/A	14	14-15	17	16-17

[1]Note: no ecological screening values are available for *Corbicula fluminea* for comparison purposes.

Appendix Z. Spatial trends of means and ranges for trace element variables from *Corbicula fluminea* in the Dan River during 2016.[1]

	Station B		Station C[2]		Station E	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	223	191-248	NA	NA	284	276-297
Antimony	0.002	N/A	NA	NA	0.004	N/A
Arsenic	0.42	0.40-0.45	NA	NA	0.42	0.41-0.43
Barium	3.86	3.52-4.08	NA	NA	1.21	4.17-4.27
Beryllium	0.014	0.012-0.017	NA	NA	0.018	0.016-0.021
Boron	0.17	0.16-0.17	NA	NA	0.20	0.19-0.20
Cadmium	0.09	0.09-0.10	NA	NA	0.09	0.09-0.10
Chromium	1.76	1.34-2.11	NA	NA	3.84	3.70-4.08
Cobalt	0.83	0.78-0.86	NA	NA	0.37	0.36-0.38
Copper	4.66	4.61-4.68	NA	NA	6.39	6.32-6.43
Iron	273	231-297	NA	NA	466	454-484
Lead	0.16	0.13-0.17	NA	NA	0.22	0.21-0.23
Manganese	12	12-13	NA	NA	21	N/A
Mercury	0.015	0.014-0.016	NA	NA	0.012	0.011-0.012
Nickel	1.09	0.77-1.34	NA	NA	2.50	2.43-2.63
Selenium	0.48	0.44-0.50	NA	NA	0.56	0.55-0.58
Silver	0.007	0.006-0.007	NA	NA	0.009	0.008-0.009
Thallium	0.006	0.005-0.006	NA	NA	0.012	N/A
Vanadium	0.46	0.40-0.50	NA	NA	0.80	0.75-0.87
Zinc	20	19-20	NA	NA	23	N/A

Appendix Z. (cont.)

	Station F		Station G		Station H	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	212	169-289	129	122-140	162	157-165
Antimony	0.004	0.003-0.004	0.002	0.002-0.003	0.004	0.003-0.006
Arsenic	0.42	0.30-0.58	0.42	0.41-0.42	0.42	0.42-0.43
Barium	4.23	3.32-5.70	3.59	3.51-3.67	3.24	3.17-3.28
Beryllium	0.018	0.016-0.022	0.008	0.006-0.012	0.008	N/A
Boron	0.22	0.18-0.28	0.12	0.10-0.16	0.12	0.12-0.13
Cadmium	0.10	0.06-0.16	0.05	N/A	0.08	0.07-0.08
Chromium	5.72	3.67-9.47	0.70	0.67-0.75	0.45	0.42-0.52
Cobalt	0.73	0.50-1.12	0.64	0.64-0.65	0.17	0.16-0.17
Copper	7.96	5.71-9.17	6.87	6.75-7.05	3.41	3.24-3.51
Iron	392	305-445	203	194-208	194	192-195
Lead	0.28	0.18-0.40	0.12	N/A	0.13	N/A
Manganese	18	15-20	5.59	5.41-5.89	7.51	7.36-7.62
Mercury	0.016	0.009-0.024	0.015	N/A	0.008	N/A
Nickel	3.85	2.40-6.71	0.39	0.36-0.42	0.14	0.14-0.15
Selenium	0.55	0.44-0.71	0.34	0.33-0.34	0.39	0.38-0.39
Silver	0.012	0.006-0.019	0.012	N/A	0.006	0.005-0.006
Thallium	0.006	0.005-0.009	0.005	0.004-0.005	0.008	0.007-0.009
Vanadium	0.62	0.46-0.83	0.30	0.29-0.30	0.35	0.33-0.36
Zinc	25	20-35	17	17-18	22	21-23

[1]Note: no ecological screening values are available for *Corbicula fluminea* for comparison purposes.
[2]The *Corbicula fluminea* sample from the reference station Transect C during 2016 was not reported due laboratory processing error.

Appendix AA. Spatial trends of means and ranges for trace element variables from *Corbicula fluminea* in the Dan River during 2017. [1]

	Station B		Station C		Station E	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	203	185-213	169	160-186	283	273-298
Antimony	0.003	0.002-0.004	0.002	0.001-0.002	0.003	0.002-0.003
Arsenic	0.31	0.29-0.33	0.42	0.40-0.46	0.45	0.44-0.46
Barium	3.56	3.19-3.96	2.98	2.89-3.18	4.53	4.45-4.70
Beryllium	0.009	0.007-0.010	0.008	0.008-0.009	0.013	0.011-0.013
Boron	0.13	0.11-0.016	0.08	0.07-0.09	0.08	0.07-0.09
Cadmium	0.08	0.06-0.09	0.07	0.07-0.08	0.07	0.06-0.07
Chromium	3.89	1.62-5.25	5.32	4.03-7.09	7.81	6.77-8.39
Cobalt	0.41	0.38-0.46	0.31	0.29-0.34	0.38	0.34-0.40
Copper	14	9.72-17	5.04	4.55-6.01	11	9.49-12
Iron	319	300-342	347	311-388	505	477-530
Lead	0.16	0.15-0.17	0.16	0.14-0.17	0.24	N/A
Manganese	13	9.63-15	9.06	8.23-10	13	13-14
Mercury	0.019	0.017-0.021	0.016	0.015-0.016	0.016	0.015-0.016
Nickel	2.79	1.07-3.80	3.74	2.82-5.11	5.59	4.76-6.01
Selenium	0.48	0.43-0.52	0.48	0.46-0.51	0.54	0.53-0.55
Silver	0.008	0.007-0.008	0.009	0.008-0.009	0.010	0.010-0.011
Thallium	0.007	0.006-0.008	0.005	N/A	0.007	0.007-0.008
Vanadium	0.40	0.34-0.50	0.37	0.35-0.40	0.64	0.52-0.69
Zinc	20	16-23	17	16-18	21	20-21

Appendix AA. (cont.)

	Station F		Station G		Station H	
Variable	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Trace elements (µg/g)						
Aluminum	196	181-217	171	156-179	102	73-117
Antimony	0.002	N/A	0.002	N/A	0.002	0.001-0.002
Arsenic	0.54	0.51-0.55	0.38	0.36-0.42	0.46	0.44-0.47
Barium	3.87	3.60-4.28	3.06	2.88-3.18	3.01	2.63-3.42
Beryllium	0.010	0.008-0.010	0.008	0.008-0.009	0.005	0.004-0.005
Boron	0.07	0.06-0.08	0.08	N/A	0.05	0.05-0.06
Cadmium	0.09	0.08-0.10	0.07	N/A	0.06	N/A
Chromium	4.36	3.52-5.55	3.19	3.03-3.29	1.06	0.62-1.42
Cobalt	0.29	0.27-0.32	0.31	0.28-0.32	0.25	0.22-0.30
Copper	8.29	7.86-9.12	6.79	6.51-7.04	5.91	5.49-6.48
Iron	350	322-375	277	259-290	121	104-175
Lead	0.18	0.16-0.21	0.14	0.13-0.15	0.10	0.08-0.12
Manganese	10	9.05-11	13	N/A	6.42	5.07-7.22
Mercury[3]	0.017	N/A	0.013	0.011-0.016	0.009	0.009-0.010
Nickel	3.00	2.40-3.88	2.19	2.11-2.27	0.62	0.32-0.90
Selenium	0.48	0.46-0.49	0.34	0.32-0.36	0.30	0.28-0.32
Silver	0.010	0.010-0.011	0.010	0.007-0.013	0.010	0.010-0.011
Thallium	0.006	0.005-0.006	0.005	0.004-0.006	0.003	0.002-0.003
Vanadium	0.44	0.40-0.51	0.35	0.32-0.37	0.24	0.16-0.29
Zinc	19	18-20	18	N/A	27	25-30

[1]Note: no ecological screening values are available for *Corbicula fluminea* for comparison purposes.

Appendix BB. Trace element concentrations in µg/g wet weight from fish samples across sampling sites during 2015. [1]

			Element							
			Cobalt		Copper		Thallium		Lead	
Screening Values			0.12 (NC)		16 (NC)/40 (VA)		0.00412 (NC)/0.27 (VA)		Report all concentrations	
Common name	n	Transect	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Golden Redhorse	10	A	0.30	0.12-0.63[1]	0.24	0.15-0.31	0.0034	0.0023-0.0040	<0.0024	<0.0024-0.0037
	10	B	0.22	0.09-0.41	0.29	0.23-0.36	0.0016	0.0006-0.0036	<0.0024	N/A
	10	D	0.22	0.09-0.34	0.24	0.15-0.29	0.0017	0.0005-0.0045	<0.0024	N/A
	10	E	0.26	0.12-0.67	0.23	0.20-0.27	0.0016	0.0006-0.0059	<0.0024	<0.0024-0.0058
	10	F	0.41	0.12-1.05	0.46	0.19-1.08	0.0027	0.0013-0.0044	0.0147	<0.0024-0.1375
	10	G	0.35	0.10-1.09	0.31	0.23-0.41	0.0022	0.0007-0.0039	<0.0024	N/A
	10	I	0.17	0.10-0.30	0.26	0.22-0.30	0.0019	0.0008-0.0030	<0.0024	N/A
Largemouth Bass	7	B	0.15	0.09-0.21	0.19	0.15-0.29	0.0041	0.0015-0.0090	<0.0024	N/A
	9	D	0.25	0.13-0.57	0.23	0.15-0.36	0.0032	0.0018-0.0060	<0.0024	<0.0024-0.0033
	8	E	0.30	0.11-0.67	0.25	0.15-0.63	0.0036	0.0027-0.0043	0.0026	<0.0024-0.0033
	4	F	0.53	0.12-1.45	0.59	0.16-1.60	0.0023	0.0015-0.0036	<0.0024	<0.0024-0.0145
	10	G	0.26	0.22-0.39	0.81	0.25-1.31	0.5871	0.0009-0.0045	<0.0024	N/A
	9	I	0.34	0.12-1.01	0.27	0.19-0.41	0.0029	0.0015-0.0050	<0.0024	N/A
Bluegill	10	I	0.30	0.13-0.53	0.25	0.17-0.33	0.0014	0.0006-0.0031	<0.0024	N/A
Redbreast Sunfish	10	A	0.30	0.12-0.83	0.46	0.17-1.17	0.0026	0.0008-0.0129	<0.0024	<0.0024-0.0034
	10	B	0.35	0.11-1.11	0.34	0.19-0.75	0.0013	0.0006-0.0024	<0.0024	N/A
	10	D	0.34	0.14-1.02	0.28	0.20-0.44	0.0023	0.0010-0.0037	<0.0024	N/A
	10	E	0.35	0.12-1.79	0.24	0.19-0.31	0.0012	0.0005-0.0040	0.0037	<0.0024-0.0143
	10	F	0.47	0.10-1.39	0.26	0.14-0.43	0.0025	0.0006-0.0049	<0.0024	<0.0024-0.0053
	10	G	0.37	0.09-1.49	0.26	0.20-0.36	0.0020	0.0008-0.0034	<0.0024	N/A
Smallmouth Bass	10	A	0.59	0.08-4.06	6.59	0.27-28-55	0.0026	0.0020-0.0036	<0.0024	N/A
	3	B	0.17	0.09-0.30	0.28	0.20-0.37	0.0047	0.0019-0.0083	<0.0024	<0.0024-0.0029
	1	D	0.34	0.24	0.17	0.17	0.0041	0.0041	<0.0024	N/A
	1	E	0.17	0.17	0.24	0.24	0.0020	0.0020	<0.0024	N/A
	6	F	0.24	0.12-0.52	0.25	0.15-0.33	0.0023	0.0014-0.0038	<0.0024	N/A
Rock Bass	1	E	0.22	0.22	0.34	0.34	0.0034	0.0034	<0.0024	N/A

[1]Items HIGHLIGHTED indicate at least one fish contained readings above screening values. Ranges with single values were from a single fish (n=1).

Appendix CC. Trace elements observed above screening values by element for fish samples by species collected in 2015.

COBALT	Transect A (NC)	Transect B (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect I (VA)
Golden Redhorse	10	9	8	10	0	0	0
Largemouth Bass	0	5	9	7	0	0	0
Bluegill	0	0	0	0	0	0	0
Redbreast Sunfish	10	9	9	8	0	0	0
Smallmouth Bass	7	2	1	1	0	0	0
Rock Bass	0	0	0	1	0	0	0
COPPER	Transect A (NC)	Transect B (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect I (VA)
-Golden Redhorse	10	0	0	0	0	0	0
Largemouth Bass	0	0	0	0	0	0	0
Bluegill	0	0	0	0	0	0	0
Redbreast Sunfish	0	0	0	0	0	0	0
Smallmouth Bass	2	0	0	0	0	0	0
Rock Bass	0	0	0	0	0	0	0
THALLIUM	Transect A (NC)	Transect B (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect I (VA)
Golden Redhorse	3	0	1	1	2	0	0
Largemouth Bass	0	2	1	2	0	0	1
Bluegill	0	0	0	0	0	0	0
Redbreast Sunfish	1	0	0	0	2	0	0
Smallmouth Bass	0	1	0	0	0	0	0
Rock Bass	0	0	0	0	0	0	0

Appendix DD. Trace element concentrations in µg/g wet weight from fish samples across sampling sites during 2016. [1]

			Element					
			Cobalt		Thallium		Lead	
Screening Values			0.12 (NC)		0.00412 (NC)/0.27 (VA)		Report all concentrations	
Common name	n	Transect	Mean	Range	Mean	Range	Mean	Range
Silver Redhorse	9	I	0.27	0.06-0.54	0.0024	0.0003-0.0072	0.0036	< 0.0024-0.0089
Golden Redhorse	9	A	0.11	0.01-0.30	0.0022	0.0006-0.0064	< 0.0024	< 0.0024-0.0026
	9	B	0.12	0.08-0.19	0.0022	0.0006-0.0062	< 0.0024	< 0.0024-0.0043
	9	D	0.17	0.08-0.28	0.0016	0.0005-0.0026	< 0.0024	N/A
	9	E	0.31	0.12-0.70	0.0029	0.0006-0.0068	< 0.0024	< 0.0024-0.0035
	9	F	0.86	0.21-2.78	0.0029	0.0006-0.0088	< 0.0024	< 0.0024-0.0035
	9	G	0.17	0.07-0.36	0.0007	0.0005-0.0018	< 0.0024	< 0.0024-0.0064
								N/A
Largemouth Bass	7	B	0.29	0.06-0.50	0.0040	0.0011-0.0100	< 0.0024	< 0.0024-0.0060
	9	D	0.38	0.13-1.07	0.0025	0.0013-0.0049	< 0.0024	N/A
	8	E	0.37	0.05-0.98	0.0043	0.0013-0.0106	< 0.0024	< 0.0024-0.0043
	6	F	0.19	0.06-0.42	0.0028	0.0020-0.0056	< 0.0024	< 0.0024-0.0034
	9	G	0.39	0.04-1.03	0.0022	0.0005-0.0038	< 0.0024	N/A
	9	I	0.32	0.05-1.05	0.0036	0.0018-0.0079	< 0.0024	< 0.0024-0.0061
Bluegill	2	G	0.20	0.11-0.30	0.0039	0.0007-0.0071	0.0033	< 0.0024-0.0058
	8	I	0.35	0.08-0.93	0.0020	0.0005-0.0039	< 0.0024	< 0.0024-0.0073
Redbreast Sunfish	9	A	0.24	0.09-0.83	0.0021	0.0005-0.0049	< 0.0024	< 0.0024-0.0042
	9	B	0.14	0.07-0.19	0.0031	0.0006-0.0070	< 0.0024	< 0.0024-0.0095
	9	D	0.32	0.07-1.21	0.0025	0.0009-0.0063	< 0.0024	< 0.0024-0.0064
	9	E	0.41	0.15-0.91	0.0012	0.0006-0.0040	< 0.0024	< 0.0024-0.0025
	9	F	0.61	0.07-2.86	0.0031	0.0006-0.0069	< 0.0024	N/A
	7	G	0.24	0.04-0.83	0.0025	0.0005-0.0067	< 0.0024	< 0.0024-0.0052
Smallmouth Bass	9	A	0.26	0.10-0.72	0.0013	0.0006-0.0027	< 0.0024	< 0.0024-0.0027
	2	B	0.57	0.14-1.01	0.0016	0.0013-0.0020	< 0.0024	N/A
	1	E	0.19	0.19	0.0030	0.0030	< 0.0024	N/A
	3	F	0.38	0.03-1.30	0.0038	0.0018-0.0082	< 0.0024	< 0.0024-0.0052

[1]Items HIGHLIGHTED indicate at least one fish contained readings above screening values. Ranges with single values were from a single fish (n=1).

Appendix EE. Trace elements observed above screening values by element for fish samples by species collected in 2016.

COBALT	Transect A (NC)	Transect B (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect I (VA)
Golden Redhorse	3	5	8	10	0	0	0
Largemouth Bass	0	7	10	8	0	0	0
Bluegill	0	0	0	0	0	0	0
Redbreast Sunfish	6	8	8	10	0	0	0
Smallmouth Bass	9	2	0	1	0	0	0
Silver Redhorse	0	0	0	0	0	0	0
THALLIUM	Transect A (NC)	Transect B (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect I (VA)
Golden Redhorse	2	2	0	3	0	0	0
Largemouth Bass	0	3	1	5	0	0	0
Bluegill	0	0	0	0	0	0	0
Redbreast Sunfish	1	4	3	0	0	0	0
Smallmouth Bass	0	0	0	0	0	0	0
Silver Redhorse	0	0	0	0	0	0	0

Appendix FF. Trace element concentrations in µg/g wet weight from fish samples across sampling sites during 2017. [1]

			Element					
			Mercury		**Thallium**		**Lead**	
Screening Values			**0.4 (NC)/0.3 (VA)**		**0.00412 (NC)/0.27 (VA)**		**Report all concentrations**	
Common name	n	Transect	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Silver Redhorse	9	I	0.15	0.10-0.25	0.0026	0.0020-0.0042	0.0048	< 0.0024-0.0195
Golden Redhorse	10	A	0.07	0.05-0.14	0.0027	0.0020-0.0054	< 0.0024	< 0.0024-0.0026
	10	B	0.09	0.06-0.13	0.0023	0.0021-0.0026	< 0.0024	< 0.0024-0.0024
	10	D	0.13	0.08-0.22	0.0044	0.0020-0.0105	0.0030	< 0.0024-0.0083
	10	E	0.17	0.11-0.23	0.0025	0.0022-0.0027	< 0.0024	< 0.0024-0.0026
	10	F	0.15	0.09-0.26	0.0036	0.0024-0.0058	0.0025	< 0.0024-0.0034
	10	G	0.20	0.10-0.35[1]	0.0022	0.0019-0.0028	0.0027	< 0.0024-0.0079
	2	I	0.05	0.04-0.06	0.0026	0.0025-0.0027	0.0025	N/A
Largemouth Bass	9	B	0.13	0.10-0.18	0.0027	0.0022-0.0034	0.0030	< 0.0024-0.0078
	10	D	0.24	0.07-0.44	0.0035	0.0021-0.0075	0.0025	< 0.0024-0.0044
	10	E	0.22	0.17-0.37	0.0024	0.0021-0.0026	0.0022	< 0.0024-0.0025
	9	F	0.26	0.17-0.34	0.0039	0.0027-0.0049	< 0.0024	< 0.0024-0.0027
	10	G	0.29	0.17-0.42	0.0036	0.0023-0.0067	0.0063	< 0.0024-0.0427
	10	I	0.14	0.07-0.26	0.0025	0.0022-0.0028	< 0.0024	< 0.0024-0.0024
Bluegill	4	G	0.04	0.02-0.07	0.0022	0.0018-0.0024	< 0.0024	N/A
	10	I	0.08	0.05-0.10	0.0036	0.0016-0.0113	0.0031	< 0.0024-0.0106
Redbreast Sunfish	10	A	0.10	0.04-0.19	0.0035	0.0023-0.0055	0.0025	< 0.0024-0.0041
	10	B	0.04	0.02-0.11	0.0036	0.0020-0.0107	0.0027	< 0.0024-0.0052
	10	D	0.05	0.03-0.08	0.0027	0.0022-0.0045	< 0.0024	< 0.0024-0.0025
	10	E	0.05	0.04-0.07	0.0033	0.0020-0.0085	0.0025	< 0.0024-0.0043
	10	F	0.05	0.04-0.06	0.0034	0.0023-0.0062	< 0.0024	< 0.0024-0.0027
	4	G	0.05	0.04-0.10	0.0024	0.0023-0.0024	< 0.0024	N/A
Smallmouth Bass	10	A	0.17	0.11-0.22	0.0030	0.0021-0.0075	0.0024	< 0.0024-0.0038
	2	B	0.14	0.14	0.0023	0.0022-0.0023	< 0.0024	N/A
	1	D	0.21	0.21	0.0025	0.0025	< 0.0024	N/A
	1	E	0.26	0.26	0.0022	0.0022	< 0.0024	N/A
	2	F	0.31	0.21-0.40	0.0037	0.0032-0.0042	0.0026	< 0.0024-0.0026
Redear Sunfish	3	G	0.06	0.03-0.08	0.0035	0.0023-0.0048	0.0024	< 0.0024-0.0025

[1]Items HIGHLIGHTED indicate at least one fish contained readings above screening values. Ranges with single values were from a single fish (n=1).

Appendix GG. Trace elements observed above screening values by element for fish samples by species collected in 2017.

MERCURY	Transect A (NC)	Transect B (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect I (VA)
Golden Redhorse	0	0	0	0	0	1	0
Largemouth Bass	0	0	1	0	1	4	0
Bluegill	0	0	0	0	0	0	0
Redbreast Sunfish	0	0	0	0	0	0	0
Smallmouth Bass	0	0	0	0	1	0	0
Silver Redhorse	0	0	0	0	0	0	0
Redear Sunfish	0	0	0	0	0	0	0
THALLIUM	Transect A (NC)	Transect B (NC)	Transect D (NC)	Transect E (NC)	Transect F (VA)	Transect G (VA)	Transect I (VA)
Golden Redhorse	1	0	4	0	0	0	0
Largemouth Bass	0	0	2	0	0	0	0
Bluegill	0	0	0	0	0	0	0
Redbreast Sunfish	5	2	1	2	0	0	0
Smallmouth Bass	1	0	0	0	0	0	0
Silver Redhorse	0	0	0	0	0	0	0
Redear Sunfish	0	0	0	0	0	0	0

Appendix HH. Benthic macroinvertebrate descriptor in the Dan River at transects through years 2015-2017.

Transect B

Descriptor	Year		
	2015	2016	2017
Total number of taxa	70	82	75
Total number of Ephemeroptera	16	16	16
Total number of Plecoptera	4	4	4
Total number of Trichoptera	10	10	10
Total number of EPT	30	30	30
Percent EPT of total taxa	42.9%	36.6%	40.0%
Total number of Intolerant taxa (0.0 - ≤ 3.3 TV)	11	10	11
Percent Intolerant taxa of total taxa	15.7%	12.2%	14.7%
Total number of Intermediate taxa (3.3 - ≤ 6.7-TV)	30	32	35
Percent Intermediate taxa of total taxa	42.9%	39.0%	46.7%
Total number of Tolerant taxa (6.8 - ≤ 10-TV)	16	18	16
Percent Tolerant taxa of total taxa	22.9%	22.0%	21.3%
Number of taxa with no established TV	13	23	13
Percent total taxa with no TV	18.6%	28.0%	17.3%
Number of EPT with no TV	7	8	6
Percent of EPT of total number of taxa with no TV	53.8%	34. 8%	46.2%

Transect C

Descriptor	Year		
	2015	2016	2017
Total number of taxa	100	97	101
Total number of Ephemeroptera	15	18	18
Total number of Plecoptera	4	3	7
Total number of Trichoptera	11	13	11
Total number of EPT	30	34	36
Percent EPT of total taxa	30.0%	35.1%	35.6%
Total number of Intolerant taxa (0.0 - ≤ 3.3 TV)	15	11	11
Percent Intolerant taxa of total taxa	15.0%	11.3%	10.9%
Total number of Intermediate taxa (3.3 - ≤ 6.7-TV)	39	35	35
Percent Intermediate taxa of total taxa	39.0%	36.1%	34.7%
Total number of Tolerant taxa (6.8 - ≤ 10-TV)	18	16	16
Percent Tolerant taxa of total taxa	18.0%	16.5%	15.8%
Number of taxa with no established TV	24	21	14
Percent total taxa with no TV	24.0%	21.6%	13.9%
Number of EPT with no TV	7	6	2
Percent of EPT of total number of taxa with no TV	29.2%	28.6%	14.3%

Appendix HH. (cont.)

Transect E

Descriptor	Year		
	2015	2016	2017
Total number of taxa	76	65	65
Total number of Ephemeroptera	17	13	14
Total number of Plecoptera	3	3	6
Total number of Trichoptera	12	6	7
Total number of EPT	32	22	27
Percent EPT of total taxa	42.1%	33.8%	41.5%
Total number of Intolerant taxa (0.0 - ≤ 3.3 TV)	13	8	14
Percent Intolerant taxa of total taxa	17.1%	12.3%	21.5%
Total number of Intermediate taxa (3.3 - ≤ 6.7-TV)	35	33	32
Percent Intermediate taxa of total taxa	46.1%	50.8%	49.2%
Total number of Tolerant taxa (6.8 - ≤ 10-TV)	14	14	7
Percent Tolerant taxa of total taxa	18.4%	21.5%	10.8%
Number of taxa with no established TV	14	10	12
Percent total taxa with no TV	18.4%	15.4%	18.5%
Number of EPT with no TV	8	5	4
Percent of EPT of total number of taxa with no TV	57.1%	50.0%	33.3%

Transect F

Descriptor	Year		
	2015	2016	2017
Total number of taxa	84	81	74
Total number of Ephemeroptera	20	17	11
Total number of Plecoptera	1	6	5
Total number of Trichoptera	12	9	10
Total number of EPT	33	32	26
Percent EPT of total taxa	39.3%	39.5%	35.1%
Total number of Intolerant taxa (0.0 - ≤ 3.3 TV)	13	14	11
Percent Intolerant taxa of total taxa	15.5%	17.3%	14.9%
Total number of Intermediate taxa (3.3 - ≤ 6.7-TV)	35	39	42
Percent Intermediate taxa of total taxa	41.7%	48.1%	56.8%
Total number of Tolerant taxa (6.8 - ≤ 10-TV)	14	11	9
Percent Tolerant taxa of total taxa	16.7%	13.6%	12.2%
Number of taxa with no established TV	19	17	12
Percent total taxa with no TV	22.6%	21.0%	16.2%
Number of EPT with no TV	4	3	1
Percent of EPT of total number of taxa with no TV	21.1%	17.6%	8.3%

Appendix HH. (cont.)

Transect G

Descriptor	Year		
	2015	2016	2017
Total number of taxa	44	42	43
Total number of Ephemeroptera	6	6	8
Total number of Plecoptera	0	0	1
Total number of Trichoptera	3	4	2
Total number of EPT	9	10	11
Percent EPT of total taxa	20.5%	23.8%	25.6%
Total number of Intolerant taxa (0.0 - ≤ 3.3 TV)	3	2	2
Percent Intolerant taxa of total taxa	6.8%	4.8%	4.7%
Total number of Intermediate taxa (3.3 - ≤ 6.7-TV)	15	16	20
Percent Intermediate taxa of total taxa	34.1%	38.1%	46.5%
Total number of Tolerant taxa (6.8 - ≤ 10-TV)	13	12	11
Percent Tolerant taxa of total taxa	29.5%	28.6%	25.6%
Number of taxa with no established TV	13	11	14
Percent total taxa with no TV	29.5%	26.2%	32.6%
Number of EPT with no TV	1	2	2
Percent of EPT of total number of taxa with no TV	7.7%	18.2%	14.3%

Transect H

Descriptor	Year		
	2015	2016	2017
Total number of taxa	64	55	64
Total number of Ephemeroptera	15	13	12
Total number of Plecoptera	4	2	4
Total number of Trichoptera	8	6	5
Total number of EPT	27	21	21
Percent EPT of total taxa	42.2%	38.2%	32.8%
Total number of Intolerant taxa (0.0 - ≤ 3.3 TV)	8	5	6
Percent Intolerant taxa of total taxa	12.5%	9.1%	9.4%
Total number of Intermediate taxa (3.3 - ≤ 6.7-TV)	27	29	31
Percent Intermediate taxa of total taxa	42.2%	52.7%	48.4%
Total number of Tolerant taxa (6.8 - ≤ 10-TV)	13	12	11
Percent Tolerant taxa of total taxa	20.3%	21.8%	17.2%
Number of taxa with no established TV	16	9	13
Percent total taxa with no TV	25.0%	16.4%	20.3%
Number of EPT with no TV	7	3	2
Percent of EPT of total number of taxa with no TV	43.8%	33.3%	15.4%

Appendix II. Fish taxa collected from the Dan River and Kerr Reservoir by all geartypes during 2015.[1]

Scientific Name[1]	Common Name	Transect A	Transect B	Transect D	Transect E	Transect F	Transect G	Transect I
Lepisosteidae	**Gars**							
Lepisosteus osseus	Longnose Gar	0	0	0	0	7	1	2
Amiidae	**Bowfins**							
Amia calva	Bowfin	0	0	0	0	0	0	0
Clupeidae	**Herrings**							
Alosa pseudoharengus	Alewife	0	0	0	0	0	0	31
A. aestivalis	Blueback Herring	0	0	0	0	0	0	75
Dorosoma cepedianum	Gizzard Shad	0	0	25	18	3	45	454
D. petenense	Threadfin Shad	0	0	0	0	0	0	55
Cyprinidae	**Carps and Minnows**							
Nocomis leptocephalus	Bluehead Chub	169	16	24	5	127	0	0
N. raneyi	Bull Chub	204	28	147	36	230	11	0
Campostoma anomalum	Central Stoneroller	10	0	0	0	0	0	0
Notropis amoenus	Comely Shiner	9	57	25	75	37	14	0
N. chiliticus	Redlip Shiner	3	0	0	0	0	0	0
N. hudsonius	Spottail Shiner	0	29	66	16	0	146	0
N. procne	Swallowtail Shiner	0	1	6	2	9	0	0
Unidentified Notropis	Unidentified	0	0	0	0	0	0	0
Cyprinus carpio	Common Carp	0	0	6	9	3	40	12
C. carpioxcarrasius	Common Carp (Goldfish Hybrid)	0	0	0	0	0	0	0
Semotilus atromaculatus	Creek Chub	0	0	0	0	1	0	0
Luxilus cerasinus	Crescent Shiner	5	0	0	0	0	0	0
Hybognathus regius	Est. Silvery Minnow	0	0	0	0	0	2	32
Notemigonus crysoleucas	Golden Shiner	0	0	0	0	0	1	18
Cyprinella lutrensis	Red Shiner	0	0	0	1	0	0	41
C. analostana	Satinfin Shiner	84	16	33	20	60	8	69
C. spiloptera	Spotfin Shiner	0	0	0	0	3	0	5
Lythrurus ardens	Rosefin Shiner	265	21	70	67	124	33	0
Luxilus albeolus	White Shiner	536	120	252	217	284	27	1
Ctenopharyngodon idella	Grass Carp	0	0	0	0	0	0	0
Unidentified cyprinds	Unidentified	1	0	0	0	0	51	0
Catostomidae	**Suckers**							
Carpiodes cyprinus	Quillback	3	6	10	1	5	3	1
Catostomus commersonii	White Sucker	5	9	9	23	1	6	0
Unidentified Maxostoma	Unidentified	0	0	0	0	0	0	0
Moxostoma ariommum	Bigeye Jumprock	21	0	0	1	0	0	0
M. cervinum	Blacktip Jumprock	71	2	15	2	27	0	0
M. erythrurum	Golden Redhorse	35	289	110	153	59	82	21
M. collapsum	Notchlip Redhorse	3	0	0	0	8	1	70
M. macrolepidotum	Shorthead Redhorse	0	0	0	0	0	0	2
M. pappillosum	V-Lip Redhorse	15	184	72	33	20	4	0
Erimyzon oblongus	Est. Creek Chubsucker	0	0	0	0	0	0	1
E. sucetta	Lake Chubsucker	0	0	0	0	0	0	1
Hypentelium nigricans	Northern Hog Sucker	24	15	18	4	35	5	0
Hypentelium roanokense	Roanoke Hogsucker	6	0	2	0	0	0	0

Appendix II. (cont.)

Scientific Name[1]	Common Name	Transect A	Transect B	Transect D	Transect E	Transect F	Transect G	Transect I
Ictaluridae	**North American catfishes**							
Ameiurus brunneus	Snail Bullhead	270	29	21	2	6	0	0
A. catus	White Catfish	0	0	0	0	0	0	0
A. nebulosus	Brown Bullhead	0	0	1	1	0	2	0
A. platycephalus	Flat Bullhead	44	5	1	3	3	0	0
Ictalurus furcatus	Blue Catfish	0	0	0	0	0	0	9
Ictalurus punctatus	Channel Catfish	1	0	16	7	6	15	24
Noturus insignis	Margined Madtom	65	0	11	1	137	0	0
Pylodictis olivaris	Flathead Catfish	0	1	0	0	0	0	6
Esocidae	**Pikes**							
Esox niger	Chain Pickerel	0	0	0	0	0	0	5
Esox americanus	Redfin Pickerel	0	0	0	0	0	0	0
Salmonidae	**Trouts and Salmons**							
Salmo trutta	Brown Trout	1	0	0	0	0	0	0
Poeciliidae	**Livebearers**							
Gambusia holbrooki	Eastern Mosquitofish	0	0	0	0	0	1	0
Moronidae	**Temperate basses**							
Morone americana	White Perch	0	0	0	0	0	0	2
M. chrysops	White Bass	0	0	0	0	0	0	1
M. saxatilis	Striped Bass	0	0	0	0	0	0	1
Centrarchidae	**Sunfishes**							
Lepomis macrochirus	Bluegill	0	15	13	29	5	158	699
L. cyanellus	Green Sunfish	0	10	5	0	0	2	12
L.gibbosus	Pumpkinseed	0	0	0	0	0	1	1
L. auritus	Redbreast Sunfish	292	321	157	252	122	94	0
L. microlophus	Redear Sunfish	0	4	10	10	8	39	87
L. (Hybrid)	Sunfish (Hybrid)	0	3	0	0	0	1	3
L. gulosus	Warmouth	0	0	0	0	0	1	21
Micropterus salmoides	Largemouth Bass	1	39	25	35	14	67	156
M. dolomieu	Smallmouth Bass	63	19	14	10	14	1	1
Pomoxis nigromaculatus	Black Crappie	0	2	12	36	3	28	33
P. annularis	White Crappie	0	0	6	8	1	5	43
Ambloplites cavifrons	Roanoke Bass	0	2	1	0	2	0	0
A. rupestris	Rock Bass	0	1	3	3	0	0	0
Enneacanthus obeus	Banded Sunfish	0	0	0	0	0	0	0
Percidae	**Perches**							
Etheostoma flabellare	Fantail Darter	7	0	0	0	1	0	0
E. vitreum	Glassy Darter	3	3	2	0	2	0	0
E. nigrum	Johnny Darter	1	0	0	0	1	0	0
E. podostemone	Riverweed Darter	15	0	2	1	31	0	0
Percina nevisense	Chainback Darter	8	3	3	0	0	0	0
P. roanoka	Roanoke Darter	22	0	1	0	127	0	0
Perca flavescens	Yellow Perch	0	0	0	0	0	1	40
Sander vitreus	Walleye	0	0	0	0	0	0	0
Morone americana	White Perch	0	0	0	0	0	0	0
Sciaenidae	**Drums**							
Trinectes maculatus	Freshwater Drum	0	0	0	0	0	0	1
	Total number	**2,261**	**1,250**	**1,195**	**1,081**	**1,527**	**896**	**2,036**
	Total number of taxa	**33**	**28**	**36**	**32**	**35**	**32**	**36**

[1]Taxonomic nomenclature follows Page et al. (2013).

Appendix JJ. Fish taxa collected from the Dan River and Kerr Reservoir by all geartypes during 2016.[1]

Scientific Name[1]	Common Name	Transect A	Transect B	Transect D	Transect E	Transect F	Transect G	Transect I
Lepisosteidae	**Gars**							
Lepisosteus osseus	Longnose Gar	0	0	0	0	0	0	12
Amiidae	**Bowfins**							
Amia calva	Bowfin	0	0	0	0	0	0	1
Clupeidae	**Herrings**							
Alosa pseudoharengus	Alewife	0	0	0	0	0	0	0
Alosa aestivalis	Blueback Herring	0	0	0	0	0	0	116
Dorosoma cepedianum	Gizzard Shad	0	0	10	1	4	73	755
D. petenense	Threadfin Shad	0	0	0	0	0	0	854
Cyprinidae	**Carps and Minnows**							
Nocomis leptocephalus	Bluehead Chub	51	12	19	14	7	2	0
N. raneyi	Bull Chub	130	11	57	42	168	1	0
Campostoma anomalum	Central Stoneroller	2	0	0	0	0	0	0
Notropis amoenus	Comely Shiner	2	126	21	94	26	78	33
N. chiliticus	Redlip Shiner	1	0	0	0	0	0	0
N. hudsonius	Spottail Shiner	36	6	46	30	41	90	79
N. procne	Swallowtail Shiner	0	3	0	4	0	0	0
Unidentified Notropis	Unidentified	0	0	0	0	0	0	0
Cyprinus carpio	Common Carp	0	3	2	8	0	80	14
C. carpioxcarrasius	Common Carp (Goldfish Hybrid)	0	0	0	0	0	0	0
Semotilus atromaculatus	Creek Chub	0	0	0	0	0	0	0
Luxilus cerasinus	Crescent Shiner	9	0	0	0	0	0	0
Hybognathus regius	East. Silvery Minnow	0	0	0	0	0	0	58
Notemigonus crysoleucas	Golden Shiner	0	0	0	6	0	2	26
Cyprinella lutrensis	Red Shiner	0	6	0	0	0	0	2
C. analostana	Satinfin Shiner	46	4	47	48	15	10	7
C. spiloptera	Spotfin Shiner	0	0	0	0	0	0	0
Lythrurus ardens	Rosefin Shiner	148	25	43	31	59	12	0
Luxilus albeolus	White Shiner	148	88	114	362	161	17	21
Ctenopharyngodon idella	Grass Carp	0	0	0	0	0	0	0
Unidentified cyprinds	Unidentified	0	0	0	0	0	0	0
Catostomidae	**Suckers**							
Carpiodes cyprinus	Quillback	0	22	4	2	2	96	0
Catostomus commersonii	White Sucker	8	22	6	8	3	2	0
Moxostoma ariommum	Bigeye Jumprock	7	0	1	0	0	0	0
M. cervinum	Blacktip Jumprock	76	0	16	5	27	0	0
M. erythrurum	Golden Redhorse	43	213	221	174	66	134	5
M. collapsum	Notchlip Redhorse	0	26	0	0	0	11	80
M. macrolepidotum	Shorthead Redhorse	0	0	1	0	1	0	0
M. pappillosum	V-Lip Redhorse	14	83	53	43	35	3	1
Unidentified Maxostoma	Unidentified	0	0	0	0	0	0	0
Erimyzon oblongus	East. Creek Chubsucker	0	0	0	0	0	0	1
E. sucetta	Lake Chubsucker	0	0	0	0	0	0	0
Hypentelium nigricans	Northern Hog Sucker	12	6	8	9	19	0	0
H. roanokense	Roanoke Hogsucker	20	0	3	1	3	0	0

Appendix JJ. (cont.)

Scientific Name[1]	Common Name	Transect A	Transect B	Transect D	Transect E	Transect F	Transect G	Transect I
Ictaluridae	**North American catfishes**							
Ameiurus brunneus	Snail Bullhead	132	23	8	13	8	7	0
A. catus	White Catfish	0	0	0	1	0	6	1
A. nebulosus	Brown Bullhead	0	0	0	3	0	4	0
A. platycephalus	Flat Bullhead	64	11	11	13	7	0	5
Ictalurus furcatus	Blue Catfish	0	0	0	0	0	0	8
Ictalurus punctatus	Channel Catfish	0	5	38	19	16	48	30
Noturus insignis	Margined Madtom	39	3	9	2	49	0	0
Pylodictis olivaris	Flathead Catfish	0	0	0	0	0	0	3
Esocidae	**Pikes and pickerels**							
Esox niger	Chain Pickerel	0	0	0	0	0	0	3
Esox americanus	Redfin Pickerel	0	0	0	0	0	0	0
Salmonidae	**Trouts and salmons**							
Salmo trutta	Brown Trout	0	0	0	0	0	0	0
Poeciliidae	**Livebearers**							
Gambusia holbrooki	Eastern Mosquitofish	0	0	1	0	0	0	0
Moronidae	**Temperate basses**							
Morone americana	White Perch	0	0	0	0	0	0	0
M. chrysops	White Bass	0	0	0	0	0	0	0
M. saxatilis	Striped Bass	0	0	0	0	0	0	1
Centrarchidae	**Sunfishes**							
Lepomis macrochirus	Bluegill	2	36	36	20	9	212	1,462
L. cyanellus	Green Sunfish	0	0	3	0	0	11	11
L.gibbosus	Pumpkinseed	0	0	3	4	0	1	2
L. auritus	Redbreast Sunfish	175	269	174	199	173	180	4
L. microlophus	Redear Sunfish	0	24	7	11	10	138	102
L. (Hybrid)	Sunfish (Hybrid)	0	0	0	0	0	4	1
L. gulosus	Warmouth	0	1	1	0	0	2	58
Micropterus salmoides	Largemouth Bass	0	24	40	19	9	63	193
M. dolomieu	Smallmouth Bass	45	10	8	8	17	3	
Pomoxis nigromaculatus	Black Crappie	0	2	14	27	8	29	72
P. annularis	White Crappie	0	1	0	0	0	8	37
Ambloplites cavifrons	Roanoke Bass	0	6	3	3	4	0	0
A. rupestris	Rock Bass	0	0	0	0	0	0	0
Enneacanthus obeus	Banded Sunfish	0	0	0	0	0	0	1
Percidae	**Perches**							
Etheostoma flabellare	Fantail Darter	1	0	0	0	1	0	0
E. vitreum	Glassy Darter	1	0	0	0	1	0	0
E. nigrum	Johnny Darter	0	0	0	0	0	0	0
E. podostemone	Riverweed Darter	3	0	1	2	0	0	0
Percina nevisense	Chainback Darter	0	0	0	1	0	0	0
P. roanoka	Roanoke Darter	55	0	1	0	19	0	0
Perca flavescens	Yellow Perch	0	0	2	0	0	6	26
Sander vitreus	Walleye	0	0	0	0	0	0	1
Morone americana	White Perch	0	0	0	0	0	0	7
Sciaenidae	**Drums**							
Aplodinotus grunniens	Freshwater Drum	0	0	0	0	0	0	1
	Total number	**1,270**	**1,071**	**1,031**	**1,227**	**968**	**1,333**	**4,094**
	Total number of taxa	**27**	**29**	**35**	**34**	**30**	**31**	**39**

[1]Taxonomic nomenclature follows Page et al. (2013).

Appendix KK. Fish taxa collected from the Dan River and Kerr Reservoir by all geartypes during 2017.[1]

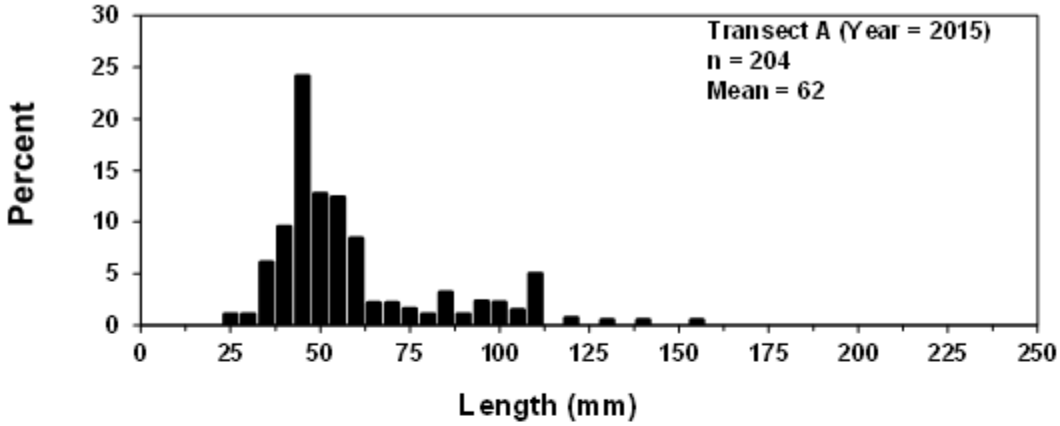
Scientific Name[1]	Common Name	Transect A	Transect B	Transect D	Transect E	Transect F	Transect G	Transect I
Lepisosteidae	**Gars**							
Lepisosteus osseus	Longnose Gar	0	0	0	0	0	0	8
Amiidae	**Bowfins**							
Amia calva	Bowfin	0	0	0	0	0	0	1
Clupeidae	**Herrings**							
Alosa pseudoharengus	Alewife	0	0	0	0	0	0	0
Alosa aestivalis	Blueback Herring	0	0	0	0	0	0	185
Dorosoma cepedianum	Gizzard Shad	0	0	4	9	6	76	783
D. petenense	Threadfin Shad	0	0	0	0	0	0	1,502
Cyprinidae	**Carps and Minnows**							
Nocomis leptocephalus	Bluehead Chub	0	0	0	0	0	0	0
Nocomis raneyi	Bull Chub	196	39	56	26	137	9	0
Campostoma anomalum	Central Stoneroller	2	0	0	0	0	0	0
Notropis amoenus	Comely Shiner	4	38	17	33	52	38	2
N. chiliticus	Redlip Shiner	20	0	0	0	0	0	0
N. hudsonius	Spottail Shiner	0	0	108	34	50	99	35
N. procne	Swallowtail Shiner	0	0	0	0	0	0	0
Unidentified Notropis	Unidentified	0	1	0	0	0	0	0
Cyprinus carpio	Common Carp	0	6	2	5	0	54	14
C. carpioxcarrasius	Common Carp (Goldfish Hybrid)	1	0	0	0	0	0	0
Semotilus atromaculatus	Creek Chub	0	0	0	1	0	0	0
Luxilus cerasinus	Crescent Shiner	31	1	2	0	1	0	0
Hybognathus regius	East. Silvery Minnow	0	0	0	0	1	0	114
Notemigonus crysoleucas	Golden Shiner	0	1	0	0	1	1	13
Cyprinella lutrensis	Red Shiner	0	0	0	0	1	0	0
C. analostana	Satinfin Shiner	290	6	119	82	76	4	5
C. spiloptera	Spotfin Shiner	0	0	0	0	0	0	0
Lythrurus ardens	Rosefin Shiner	64	4	31	14	24	0	0
Luxilus albeolus	White Shiner	161	18	100	62	49	3	0
Ctenopharyngodon idella	Grass Carp	0	0	0	0	0	1	0
Unidentified cyprinds	Unidentified	0	0	0	0	0	0	0
Catostomidae	**Suckers**							
Carpiodes cyprinus	Quillback	1	9	1	5	4	24	2
Catostomus commersonii	White Sucker	16	14	17	18	3	0	0
Unidentified Maxostoma	Unidentified	0	0	0	0	0	1	0
Moxostoma ariommum	Bigeye Jumprock	5	0	0	4	0	0	0
M. cervinum	Blacktip Jumprock	61	2	20	10	20	0	0
M. erythrurum	Golden Redhorse	94	377	154	184	84	183	8
M. collapsum	Notchlip Redhorse	0	3	3	0	5	1	69
M. macrolepidotum	Shorthead Redhorse	0	0	0	0	0	0	0
M. pappillosum	V-Lip Redhorse	56	126	64	24	92	13	0
Erimyzon oblongus	East. Creek Chubsucker	0	0	0	0	0	0	1
E. sucetta	Lake Chubsucker	0	0	0	0	0	0	0
Hypentelium nigricans	Northern Hog Sucker	17	11	7	3	22	0	0
H. roanokense	Roanoke Hogsucker	10	2	1	0	0	0	0

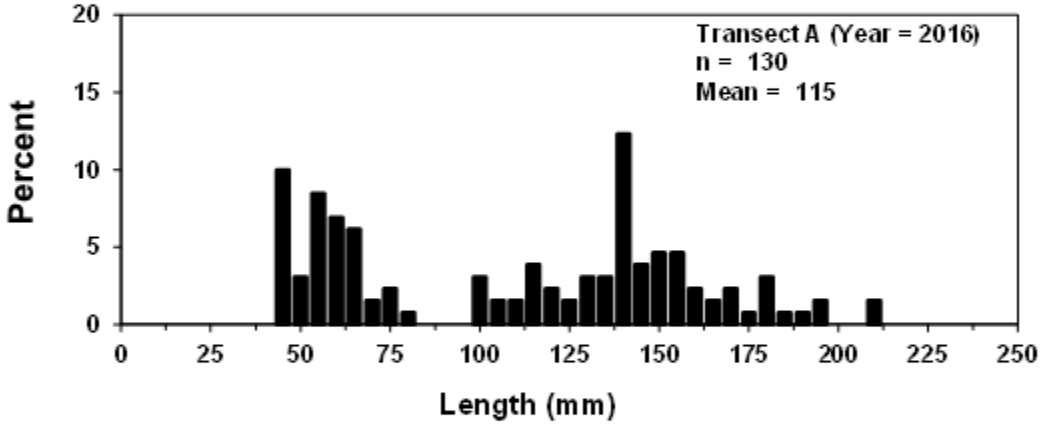
Appendix KK. (cont.)

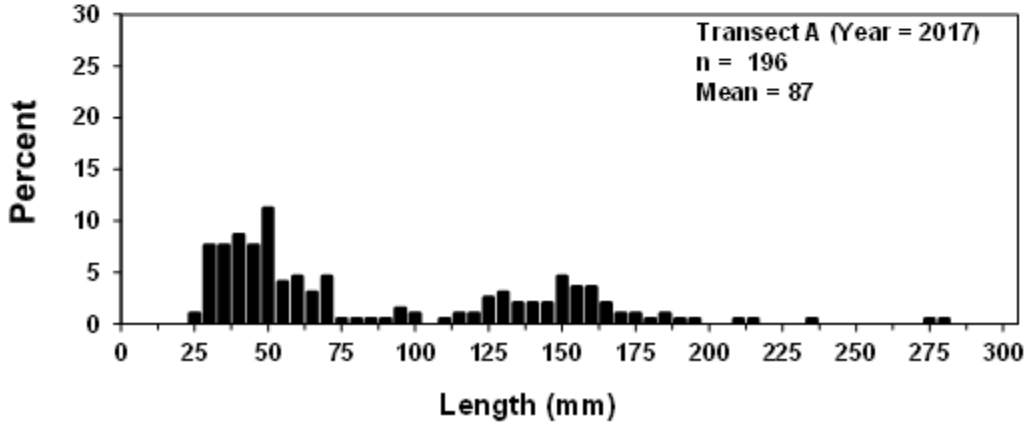
Scientific Name[1]	Common Name	Transect A	Transect B	Transect D	Transect E	Transect F	Transect G	Transect I
Ictaluridae	**North American catfishes**							
Ameiurus brunneus	Snail Bullhead	179	23	19	10	7	3	0
A. catus	White Catfish	0	0	0	0	0	5	0
A. nebulosus	Brown Bullhead	0	0	1	0	0	7	0
A. platycephalus	Flat Bullhead	74	8	7	12	4	0	0
Ictalurus furcatus	Blue Catfish	0	1	0	0	0	1	11
Ictalurus punctatus	Channel Catfish	0	22	17	8	42	65	21
Noturus insignis	Margined Madtom	64	2	6	0	78	0	0
Pylodictis olivaris	Flathead Catfish	0	1	0	0	0	0	3
Esocidae	**Pikes and pickerels**							
Esox niger	Chain Pickerel	0	0	0	0	0	0	0
Esox americanus	Redfin Pickerel	0	0	0	0	1	0	0
Salmonidae	**Trouts and salmons**							
Salmo trutta	Brown Trout	0	0	0	0	0	0	0
Poeciliidae	**Livebearers**							
Gambusia holbrooki	Eastern Mosquitofish	0	0	1	0	0	1	0
Moronidae	**Temperate basses**							
Morone americana	White Perch	0	0	0	0	0	0	12
M. chrysops	White Bass	0	0	0	0	0	0	0
M. saxatilis	Striped Bass	0	0	0	0	0	0	2
Centrarchidae	**Sunfishes**							
Lepomis macrochirus	Bluegill	8	102	97	122	71	248	711
L. cyanellus	Green Sunfish	0	2	7	3	4	3	9
L.gibbosus	Pumpkinseed	0	0	0	0	0	1	0
L. auritus	Redbreast Sunfish	374	339	466	456	302	135	3
L. microlophus	Redear Sunfish	1	34	48	41	20	95	66
L. gulosus	Warmouth	0	1	0	2	0	0	21
L. (Hybrid)	Sunfish (Hybrid)	0	0	1	0	0	0	1
Micropterus salmoides	Largemouth Bass	1	39	44	35	23	58	189
M. dolomieu	Smallmouth Bass	30	8	6	10	10	6	0
Pomoxis nigromaculatus	Black Crappie	0	0	0	0	0	0	0
P. annularis	White Crappie	0	0	0	0	0	1	15
Ambloplites cavifrons	Roanoke Bass	0	7	11	5	1	0	0
A. rupestris	Rock Bass	0	0	0	1	0	0	1
Enneacanthus obeus	Banded Sunfish	0	0	0	0	0	0	0
Percidae	**Perches**							
Etheostoma flabellare	Fantail Darter	0	0	0	0	1	0	0
E. vitreum	Glassy Darter	0	0	1	0	0	0	0
E. nigrum	Johnny Darter	0	0	0	0	0	0	0
E. podostemone	Riverweed Darter	55	0	1	0	2	0	0
Percina nevisense	Chainback Darter	0	0	8	1	0	0	0
P. roanoka	Roanoke Darter	8	0	1	0	0	0	0
Perca flavescens	Yellow Perch	0	0	0	0	0	3	22
Sander vitreus	Walleye	0	0	0	0	0	0	1
Sciaenidae	**Drums**							
Aplodinotus grunniens	Freshwater Drum	0	0	0	0	0	0	0
	Total number	**1,816**	**1,216**	**1,455**	**1,245**	**1,201**	**1,153**	**3,991**
	Total number of taxa	**27**	**33**	**36**	**30**	**33**	**31**	**32**

[1]Taxonomic nomenclature follows Page et al. (2013).

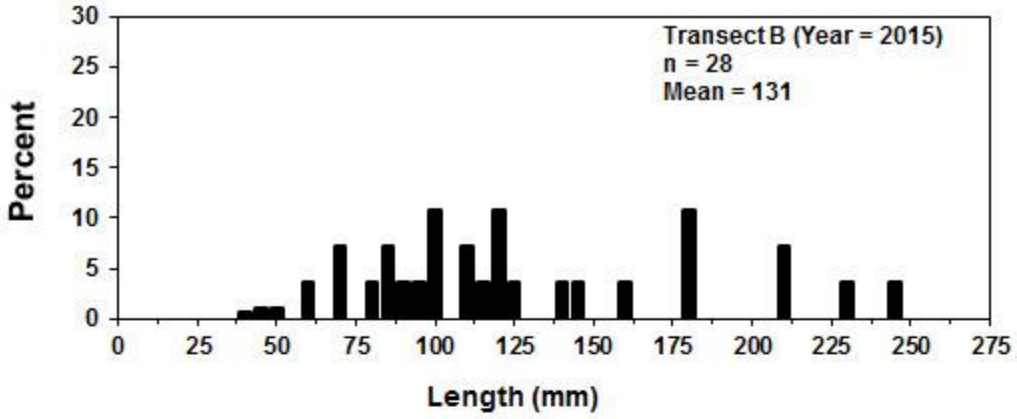
Appendix LL. Bull Chub length frequency histograms from Transects A, B, D, E and F, 2015-2017.

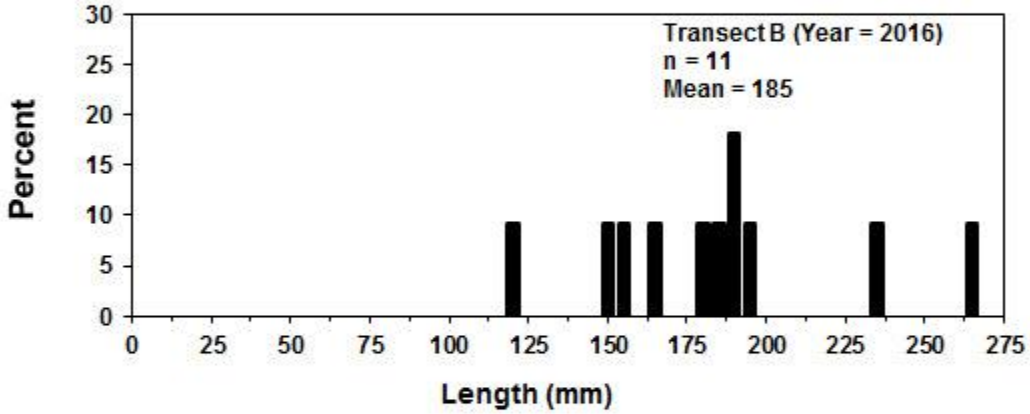


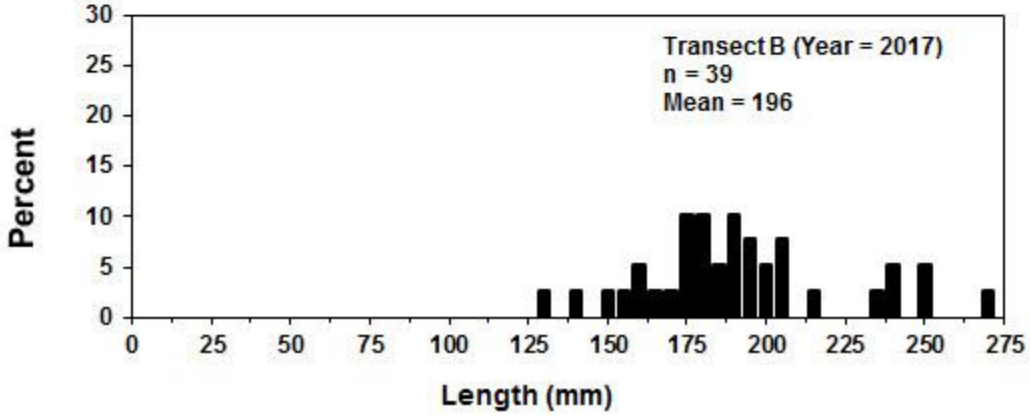




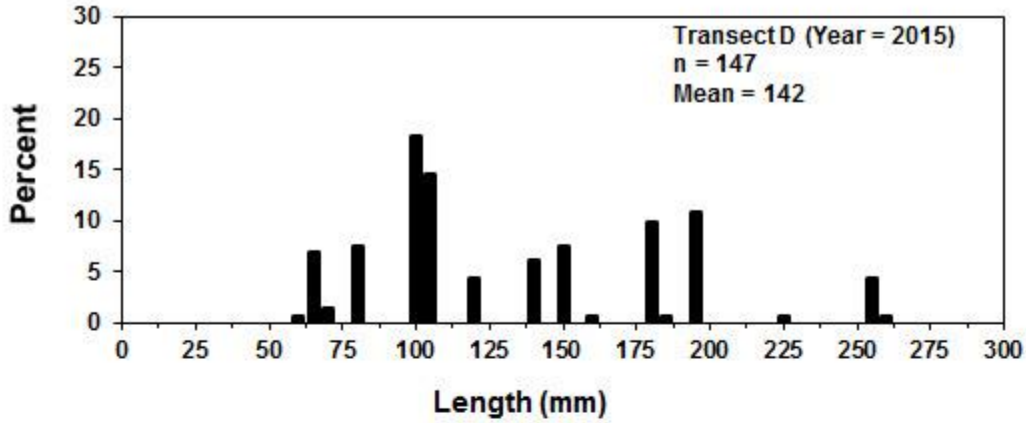
Appendix LL. (cont.)

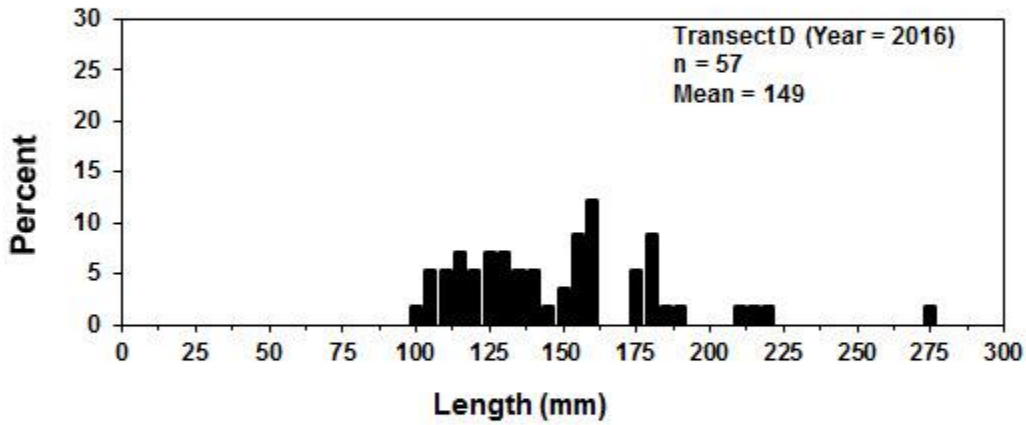


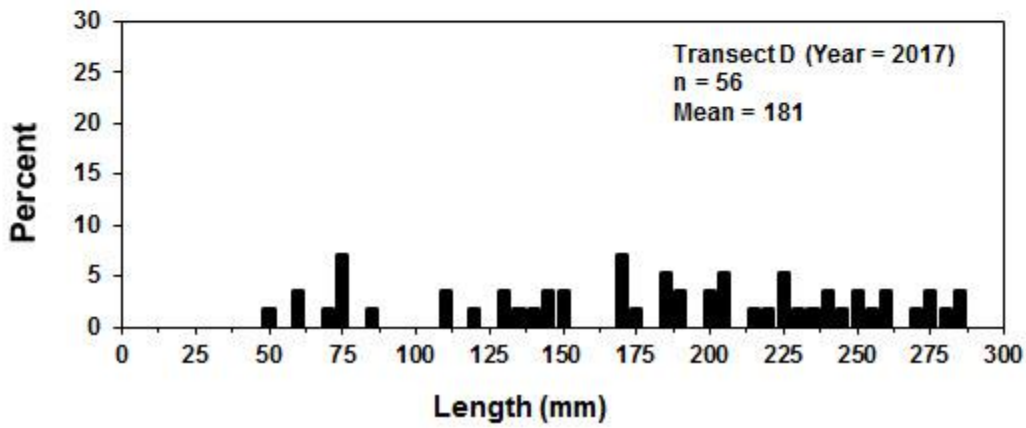




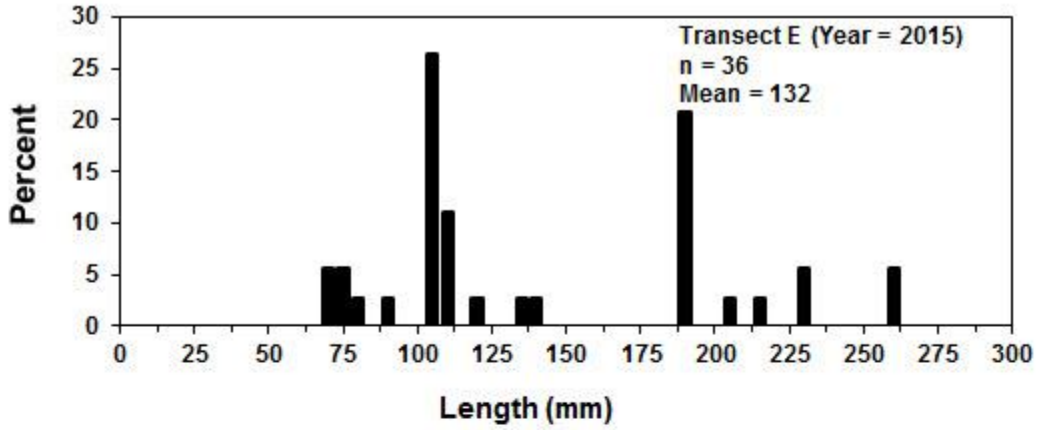
Appendix LL. (cont.)

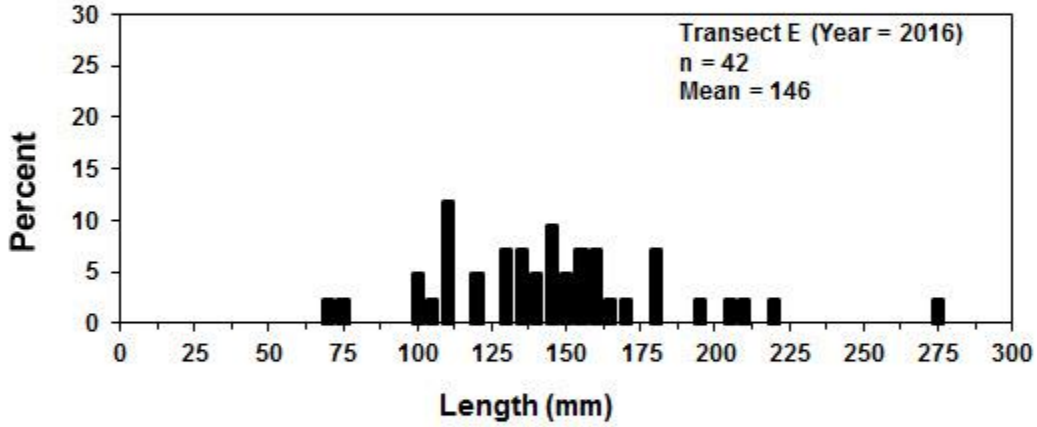


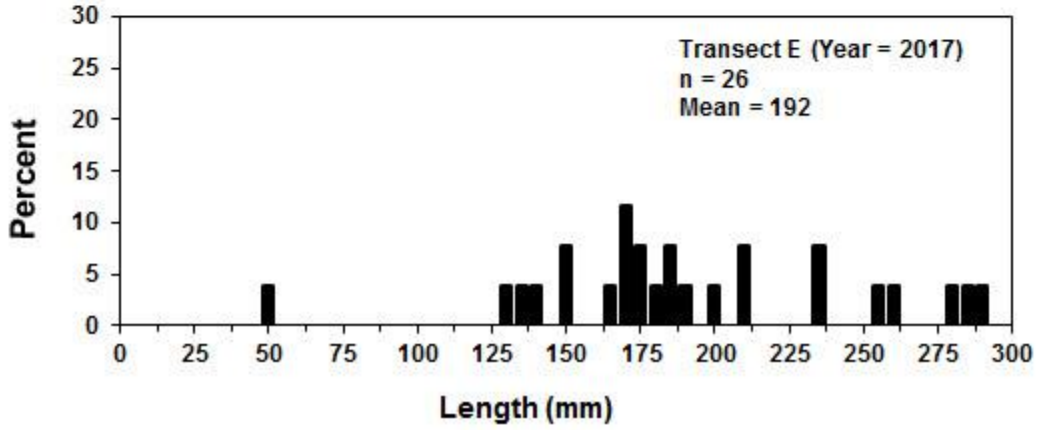




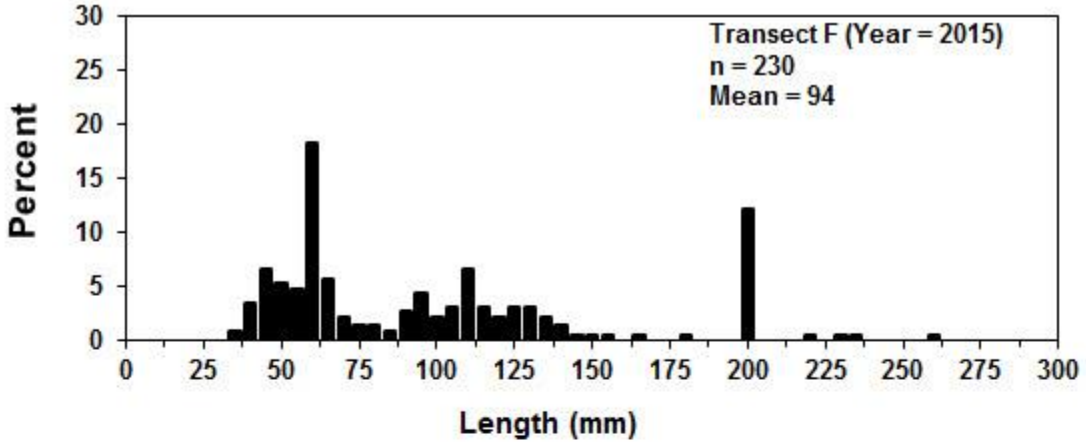
Appendix LL. (cont.)

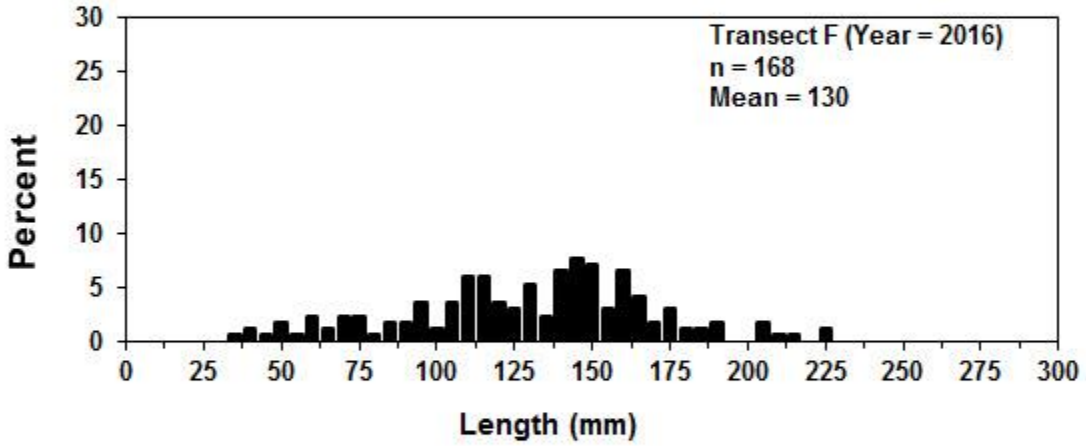


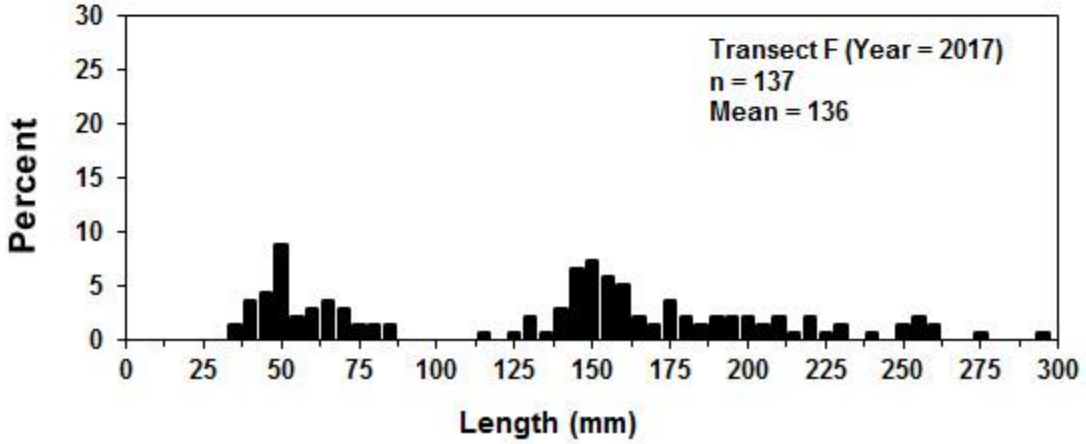




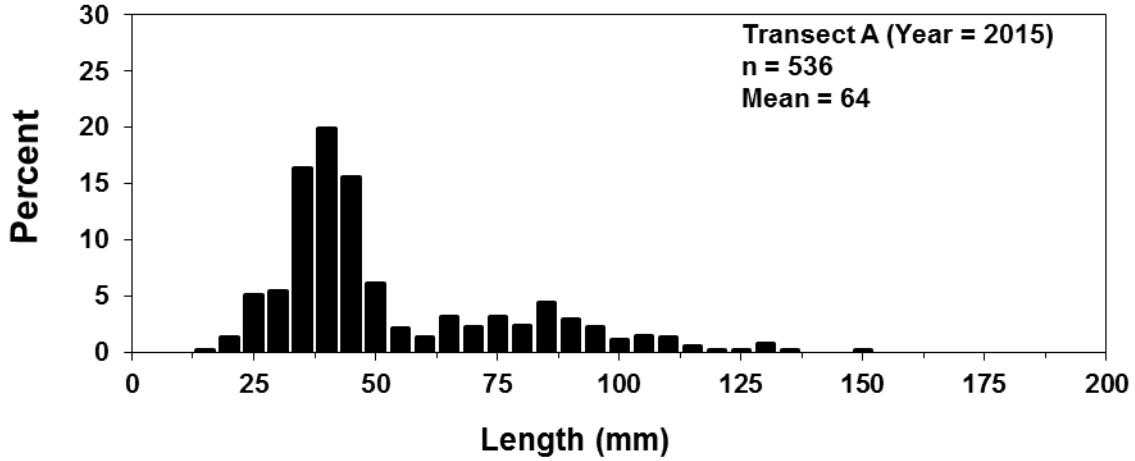
Appendix LL. (cont.)

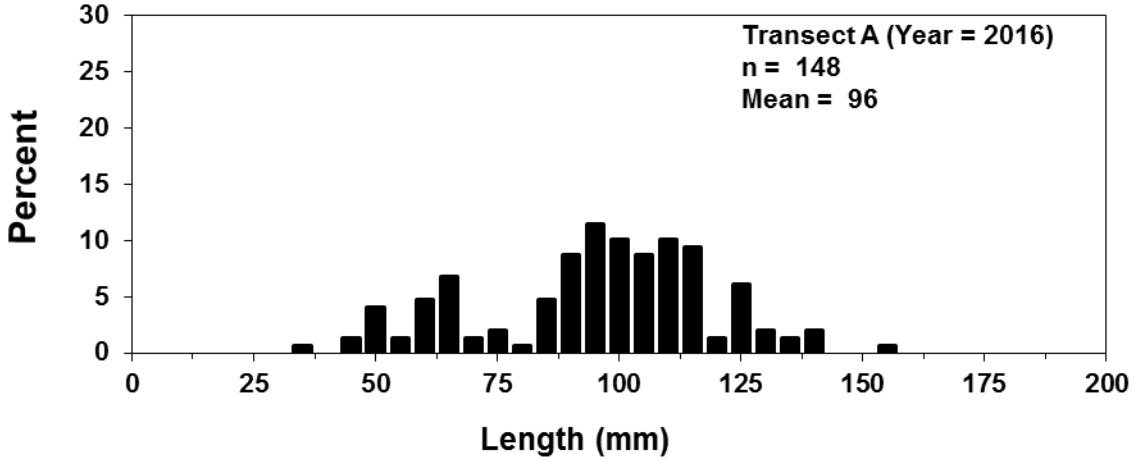


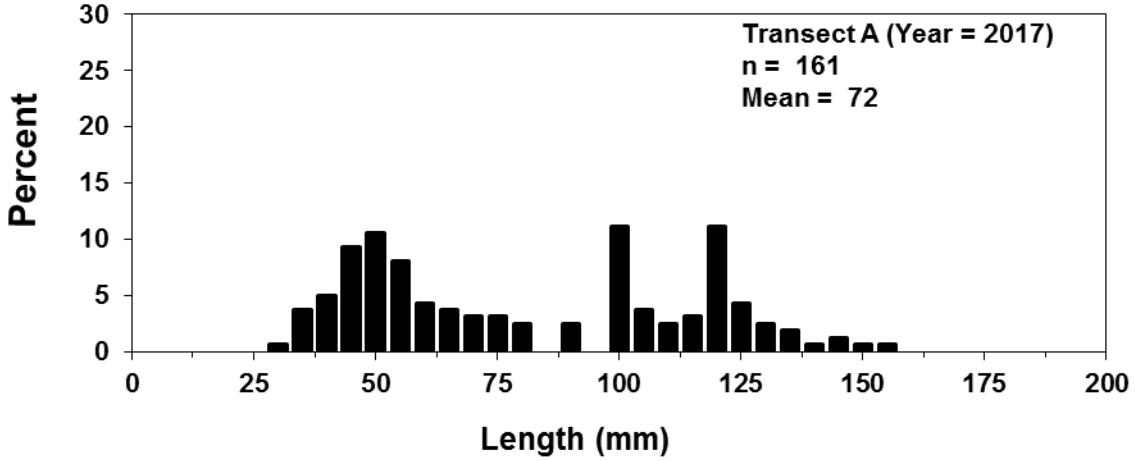




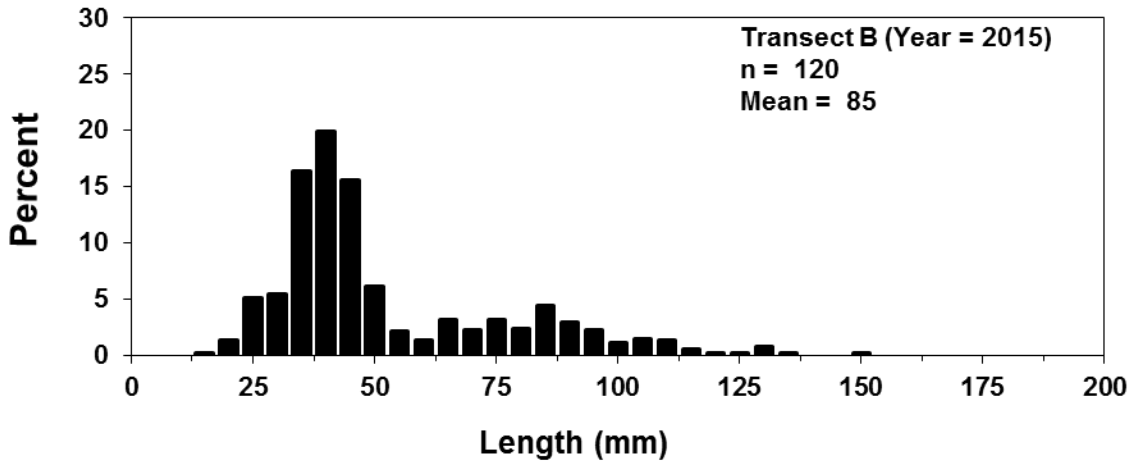
Appendix MM. White Shiner length frequency histograms from Transects A, B, D, E, F and G, 2015-2017.

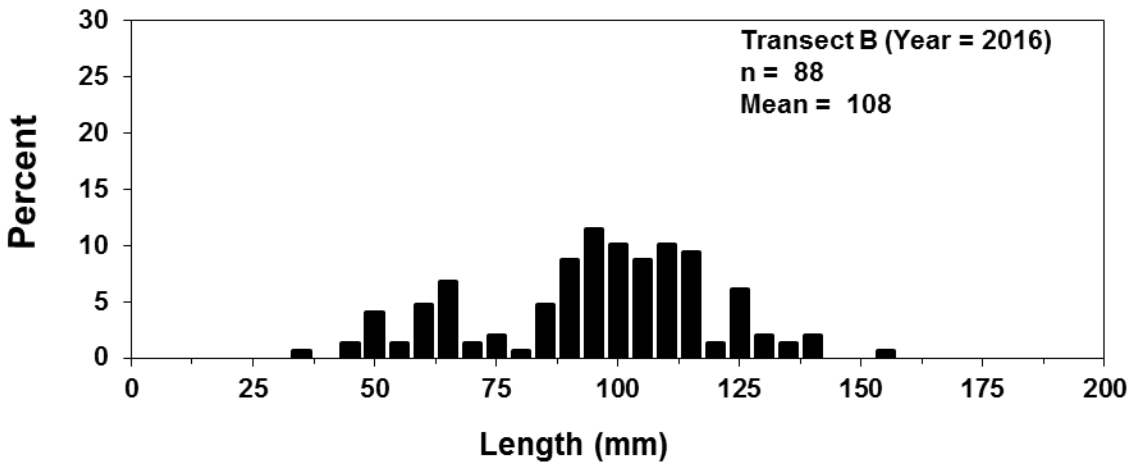


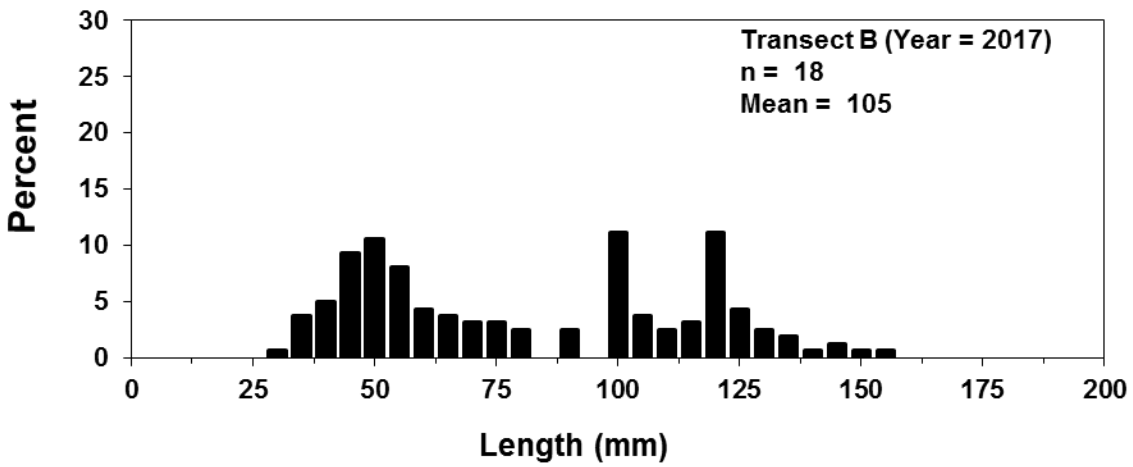




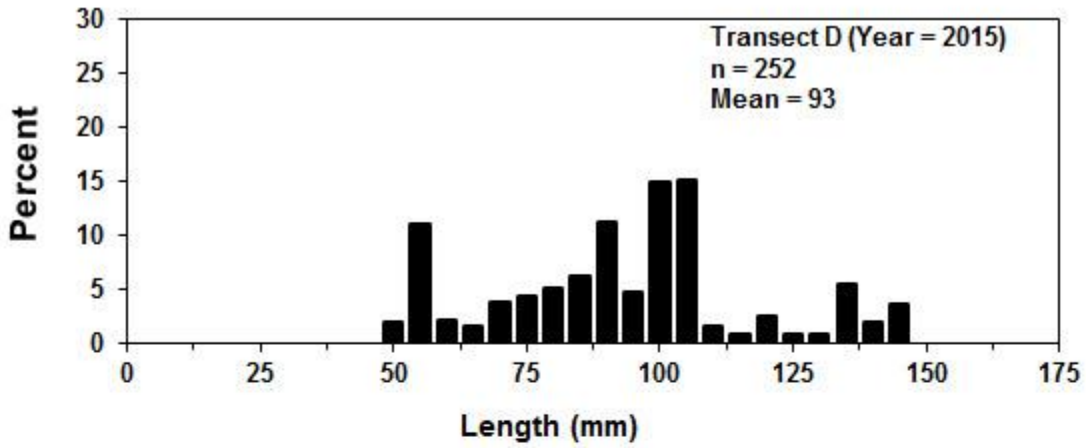
Appendix MM. (cont.)

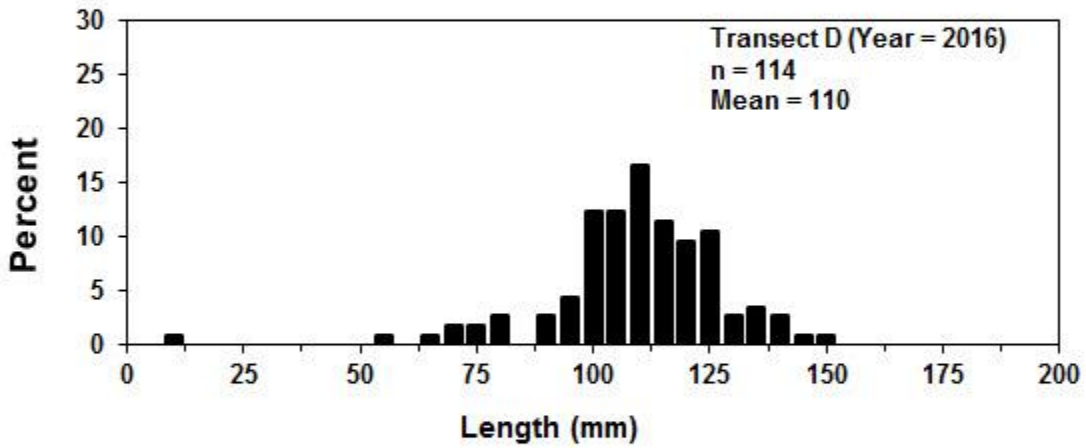


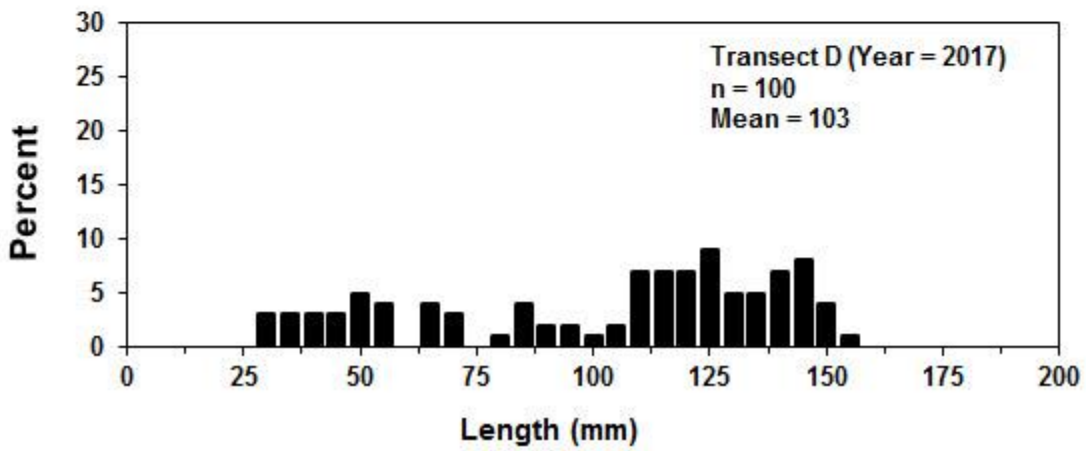




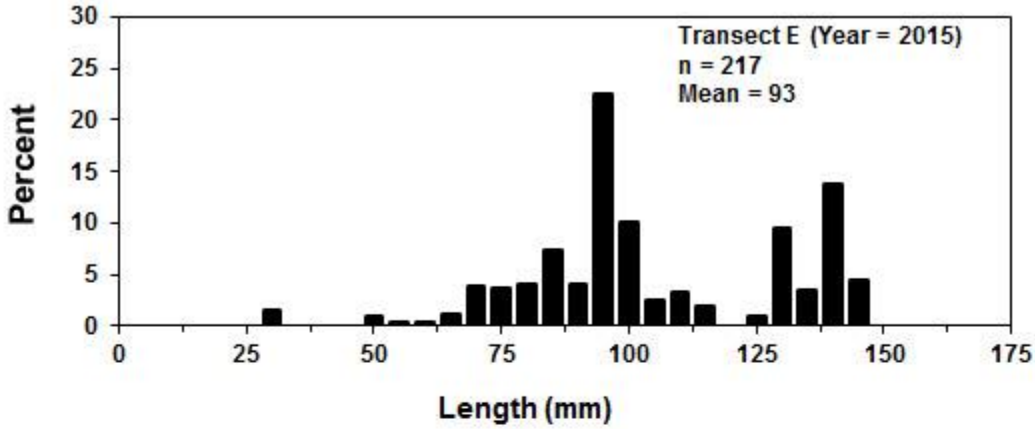
Appendix MM. (cont.)

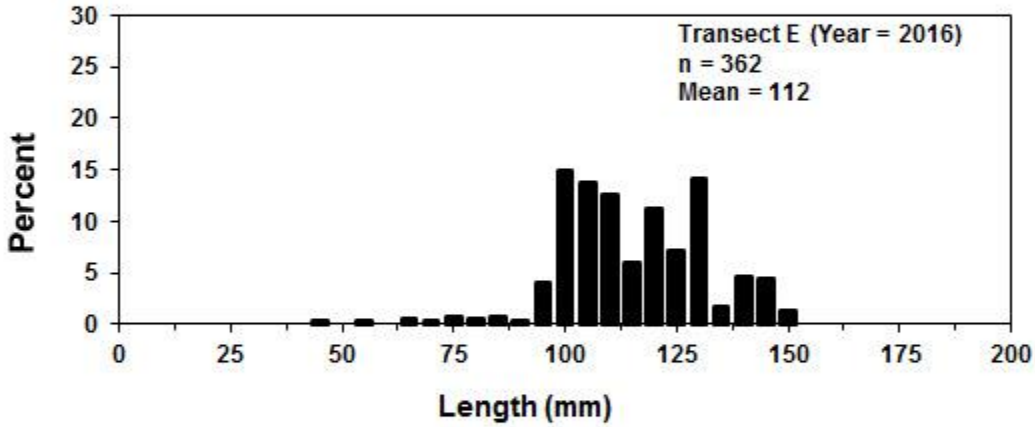


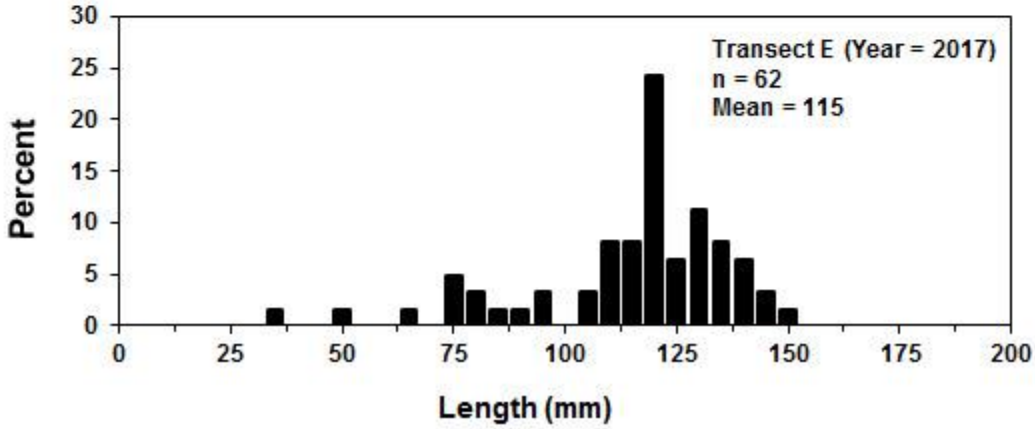




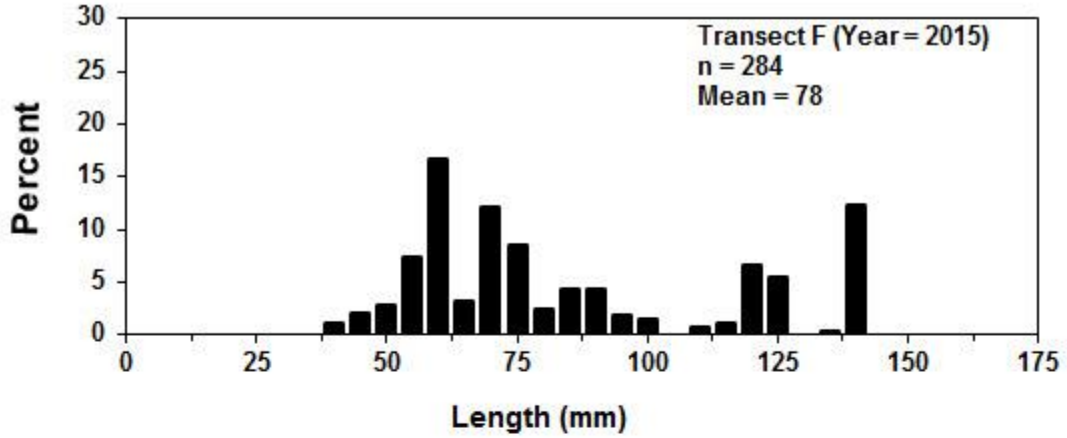
Appendix MM. (cont.)

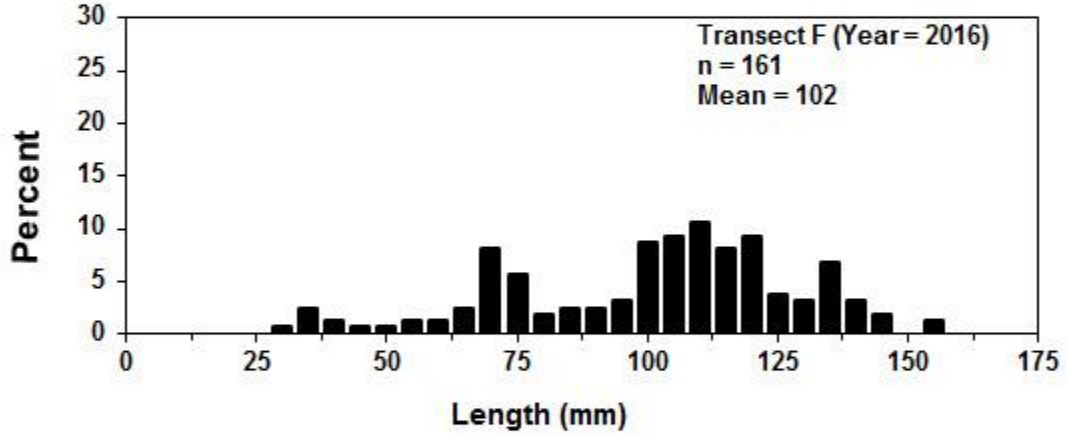


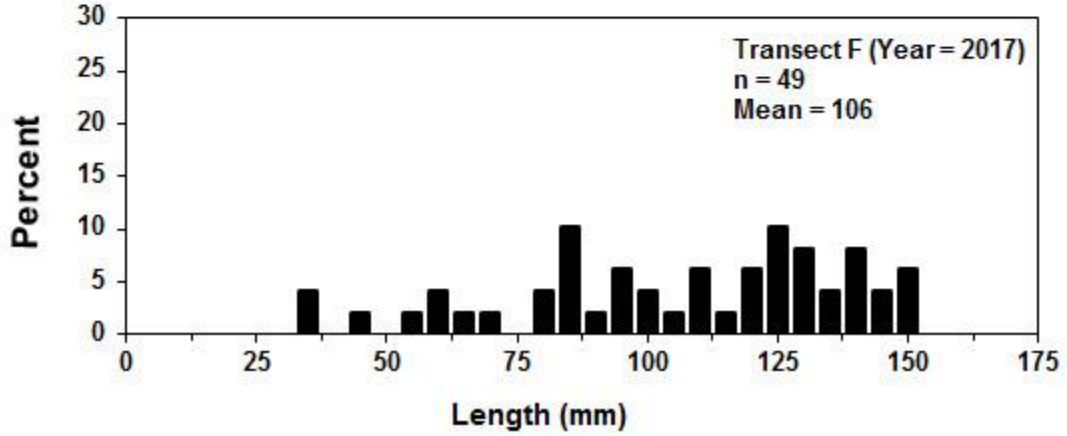




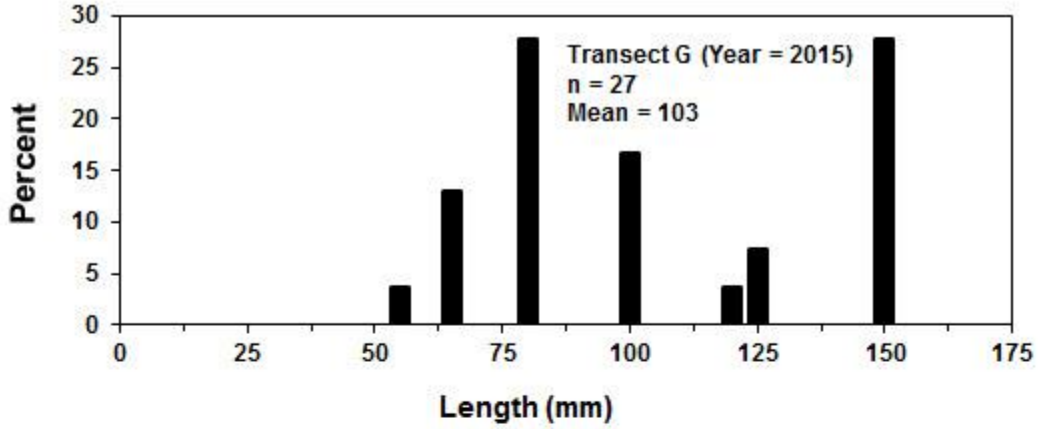
Appendix MM. (cont.)

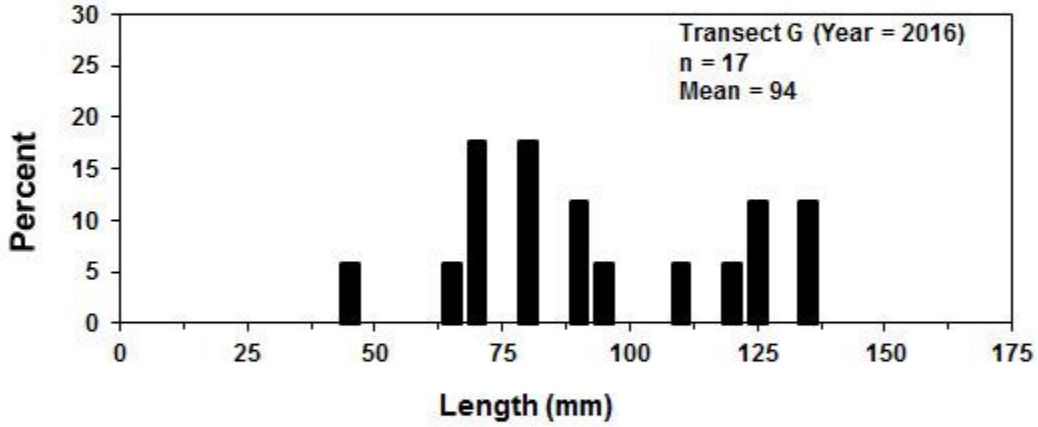


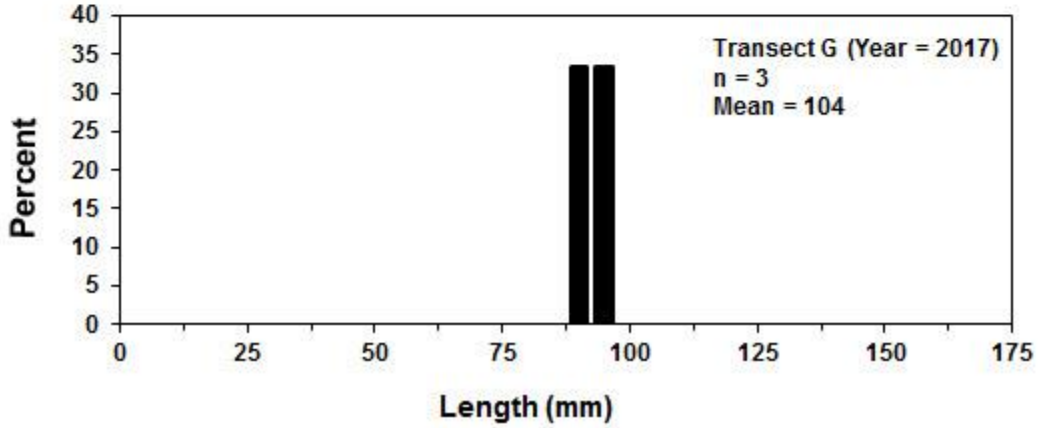




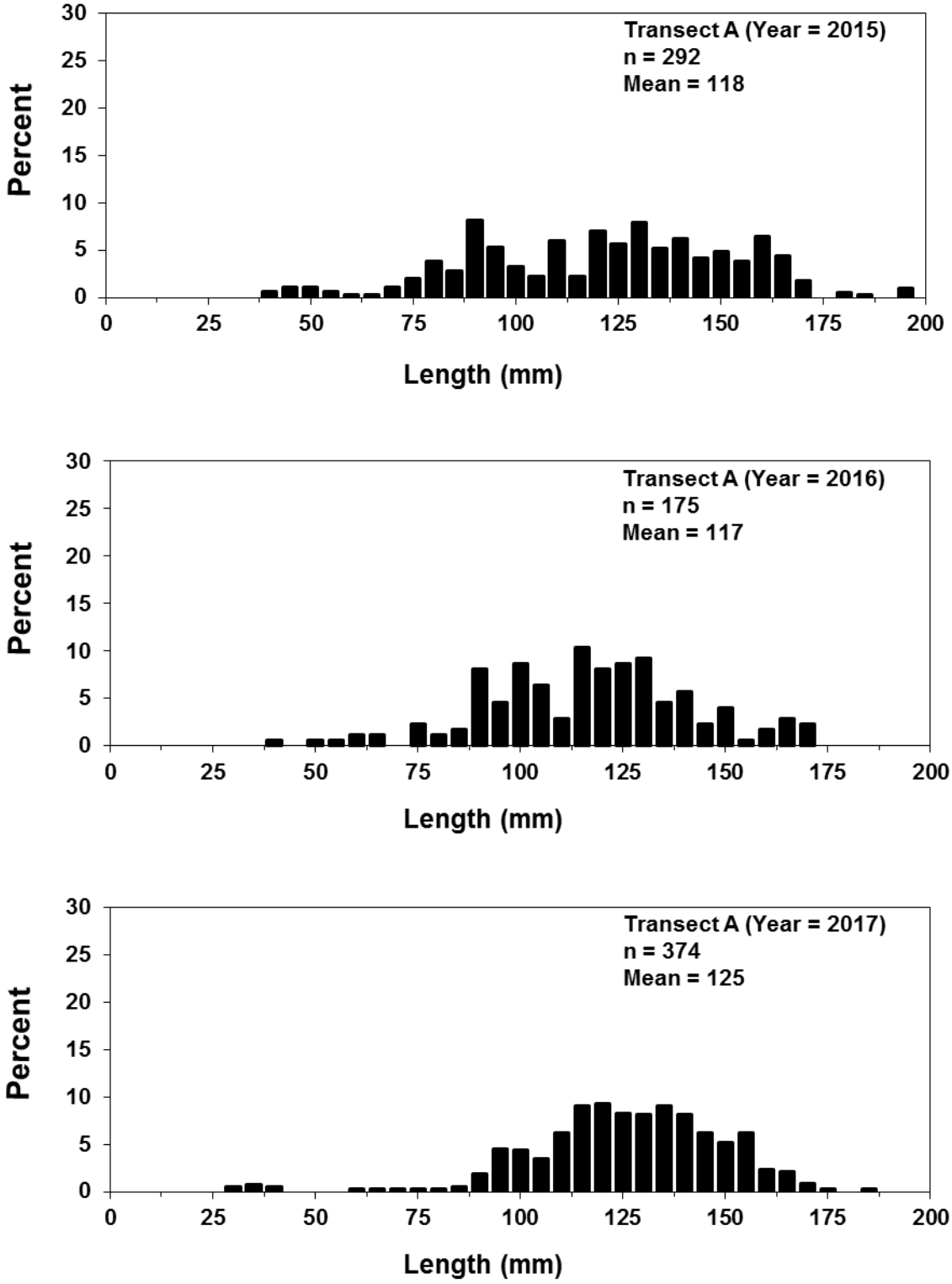
Appendix MM. (cont.)



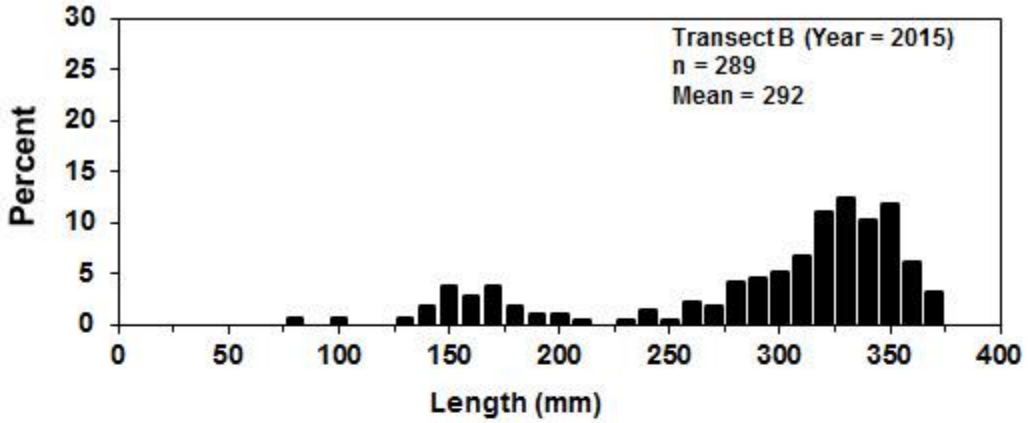


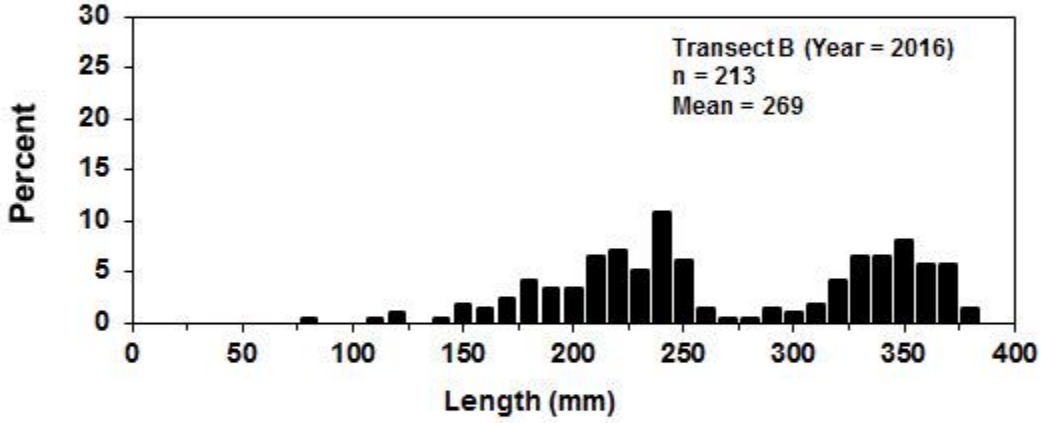


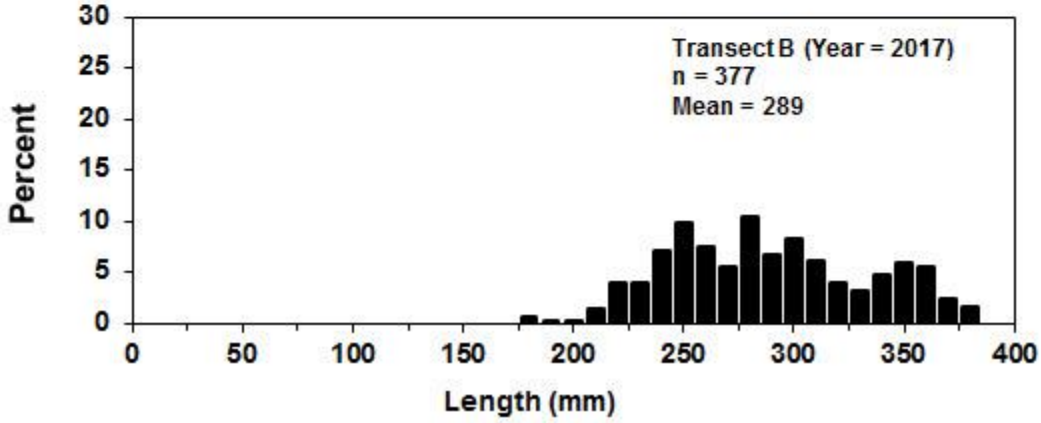
Appendix NN. Golden Redhorse length frequency histograms from Transects A, B, D, E, F and G, 2015-2017.



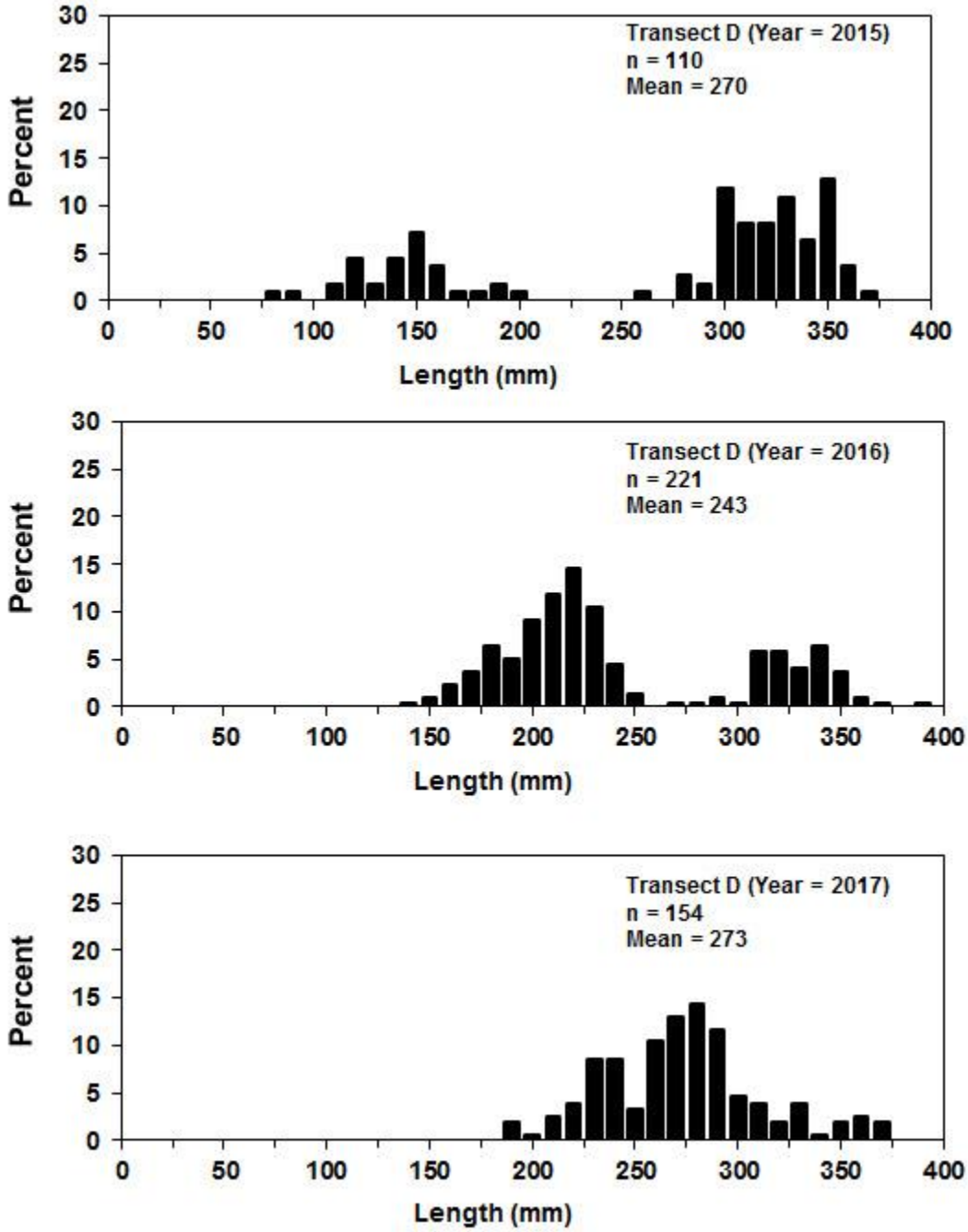
Appendix NN. (cont.)



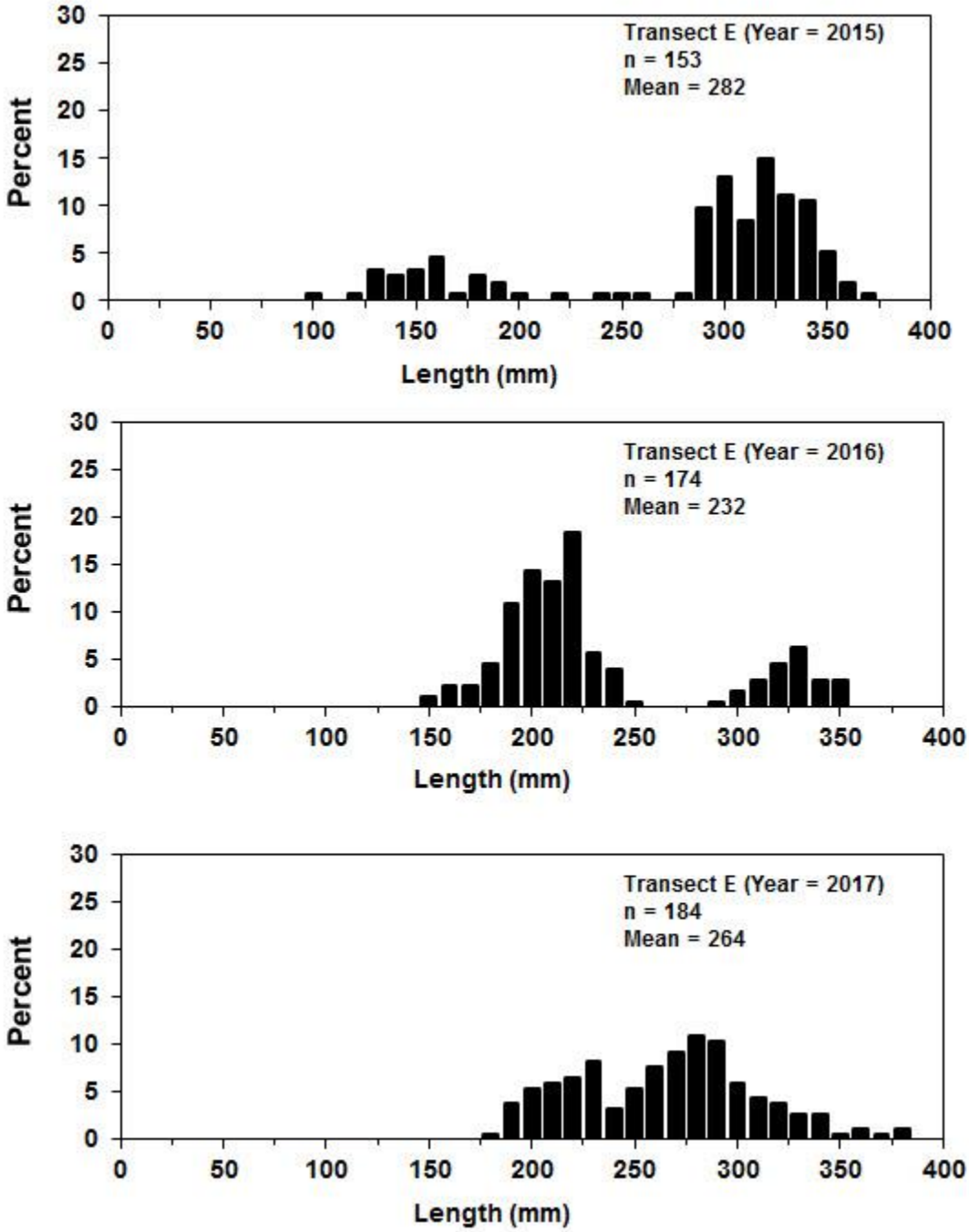




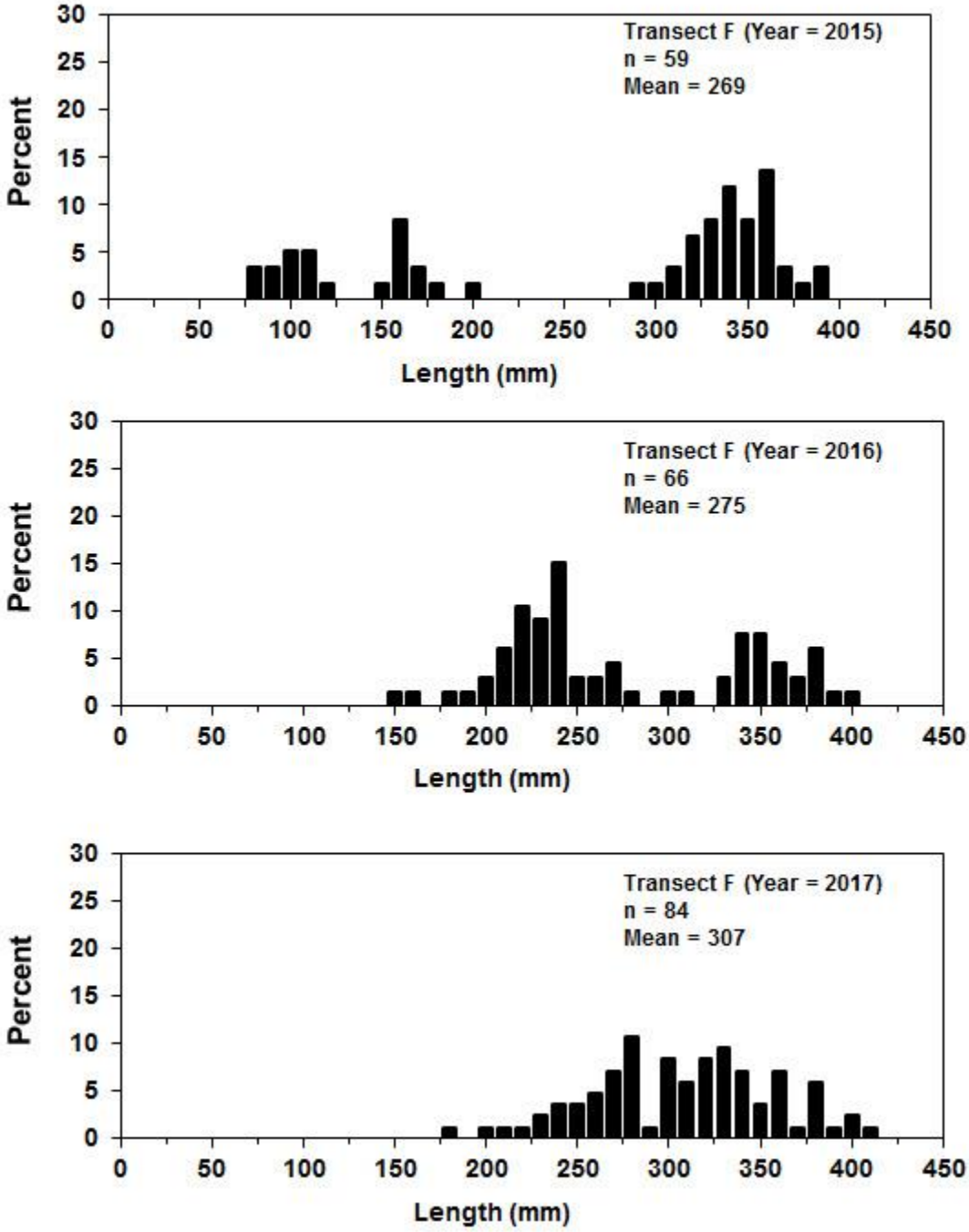
Appendix NN. (cont.)



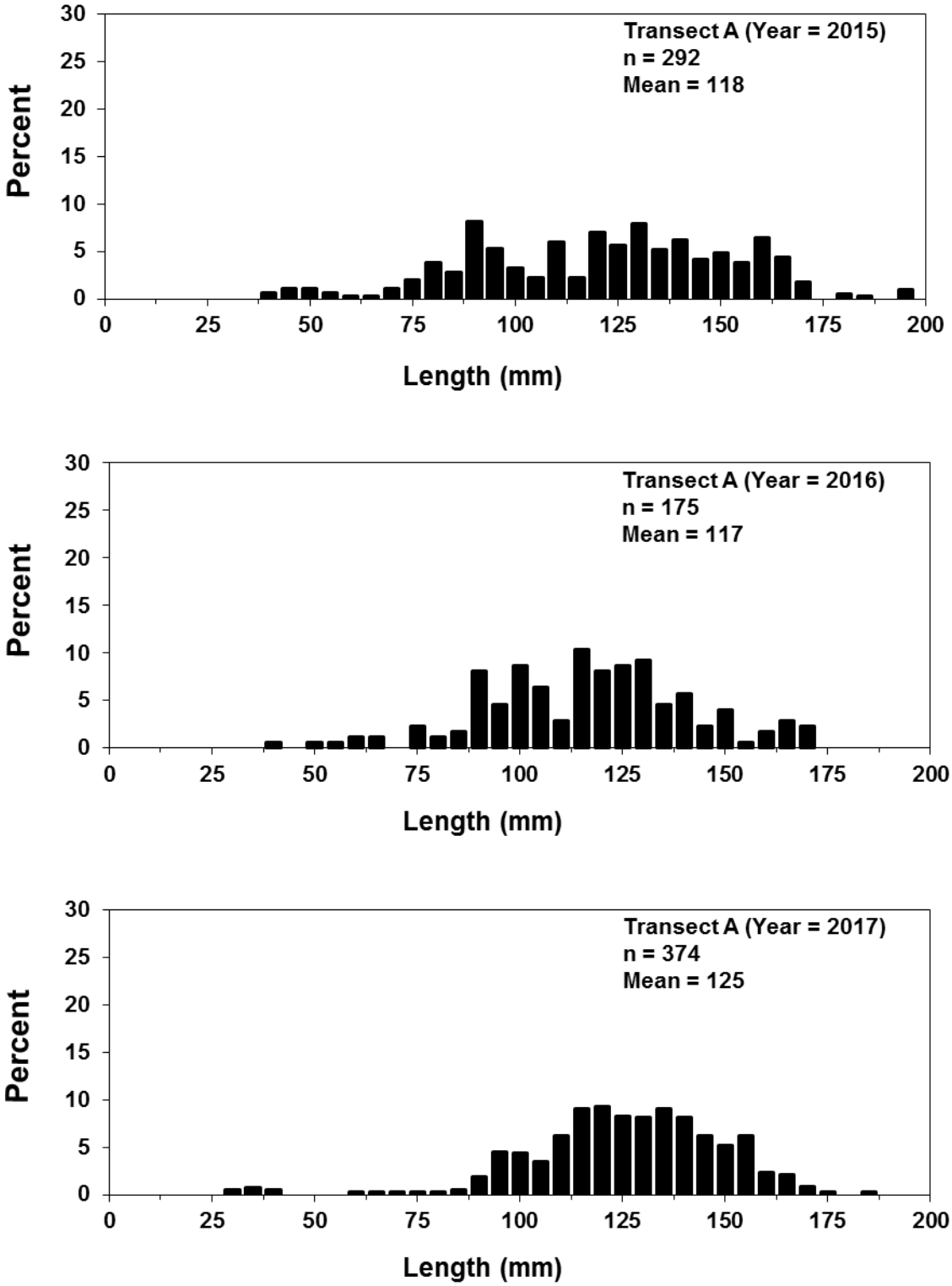
Appendix NN. (cont.)



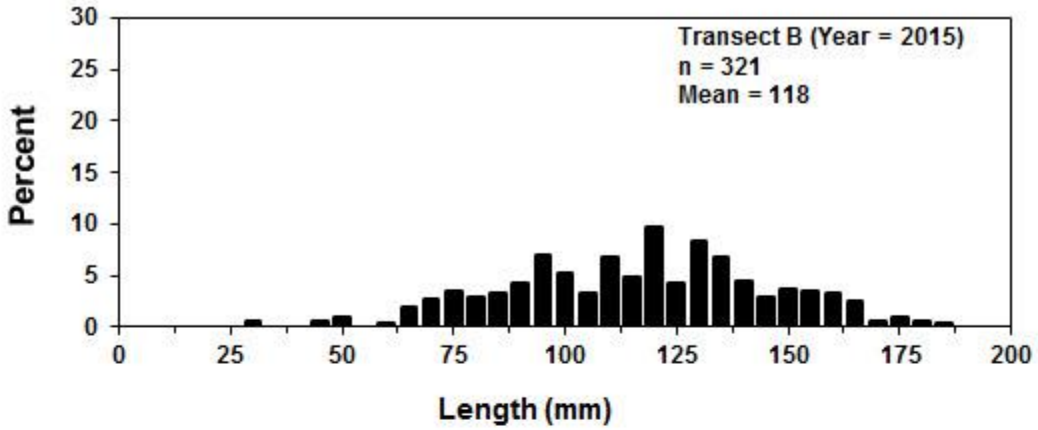
Appendix NN. (cont.)

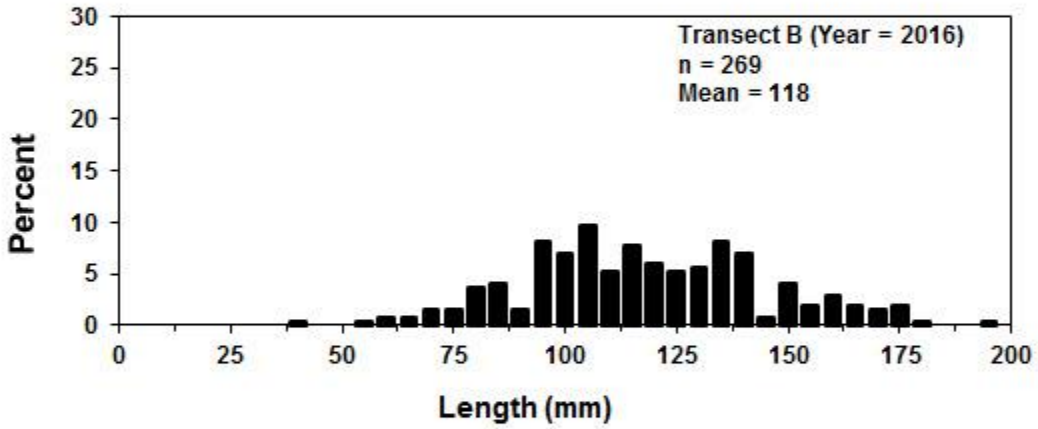


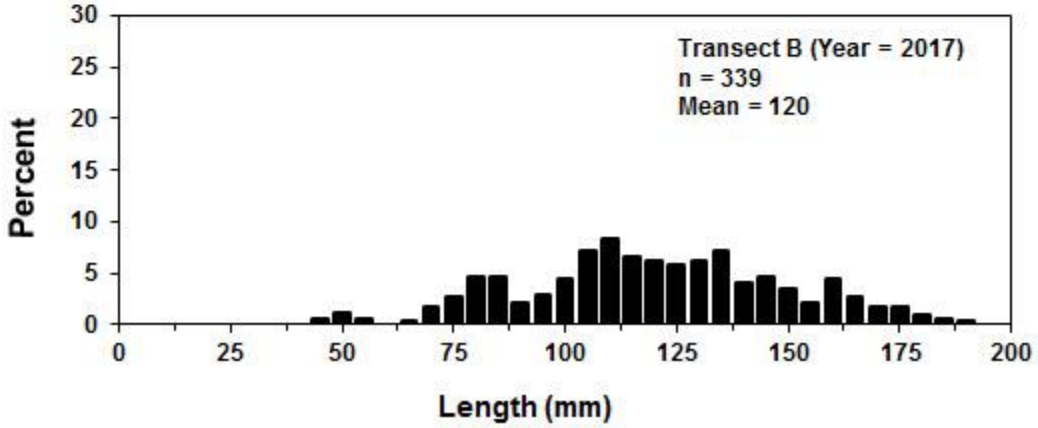
Appendix OO. Redbreast Sunfish length frequency histograms from Transects A, B, D, E, F and G, 2015- 2017.



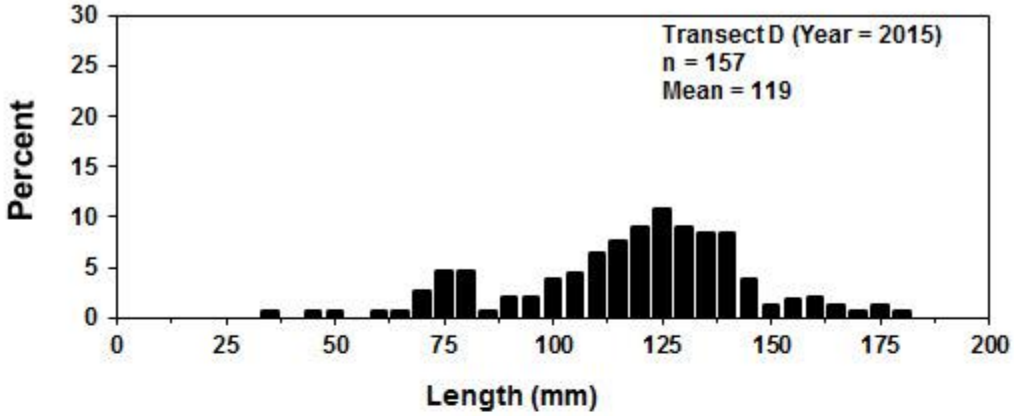
Appendix OO. (cont.)

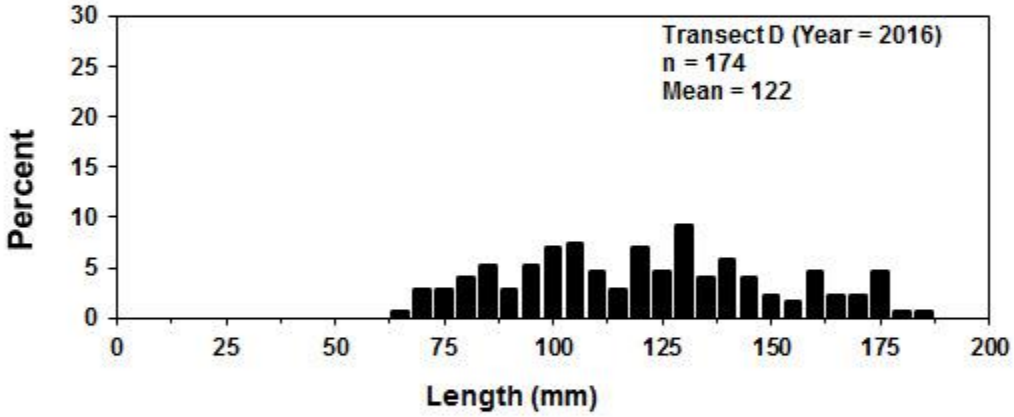


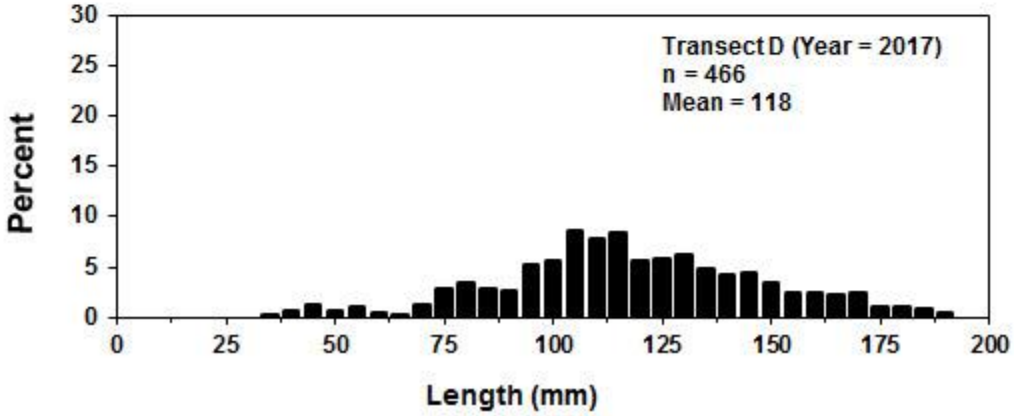




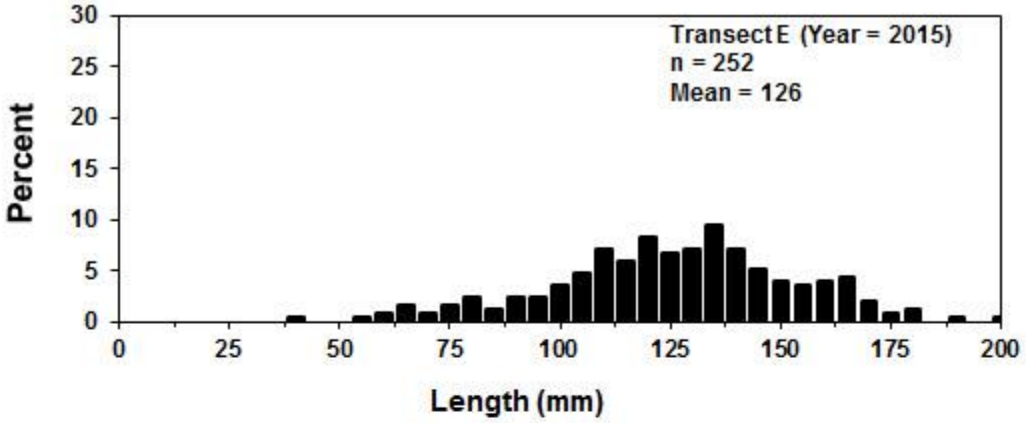
Appendix OO. (cont.)

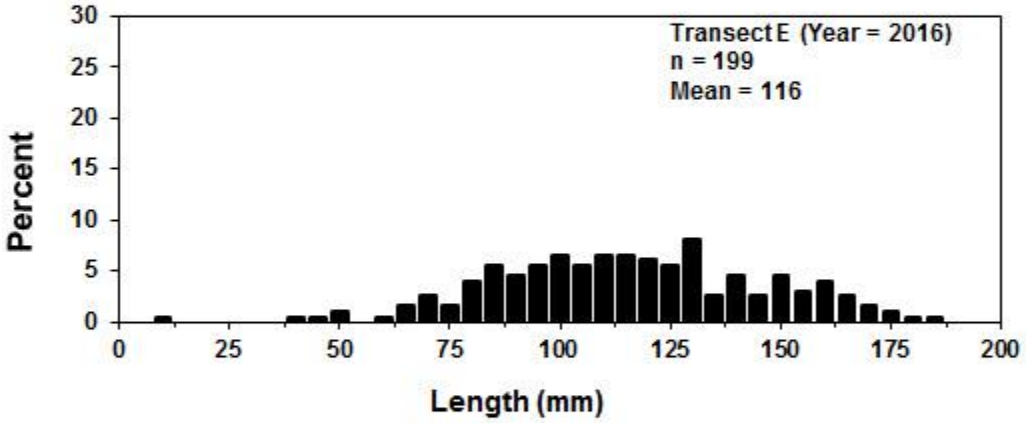


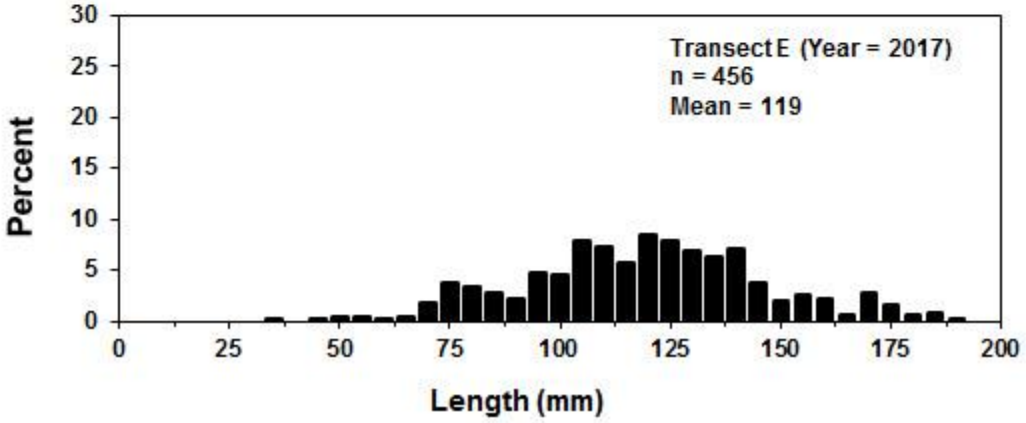




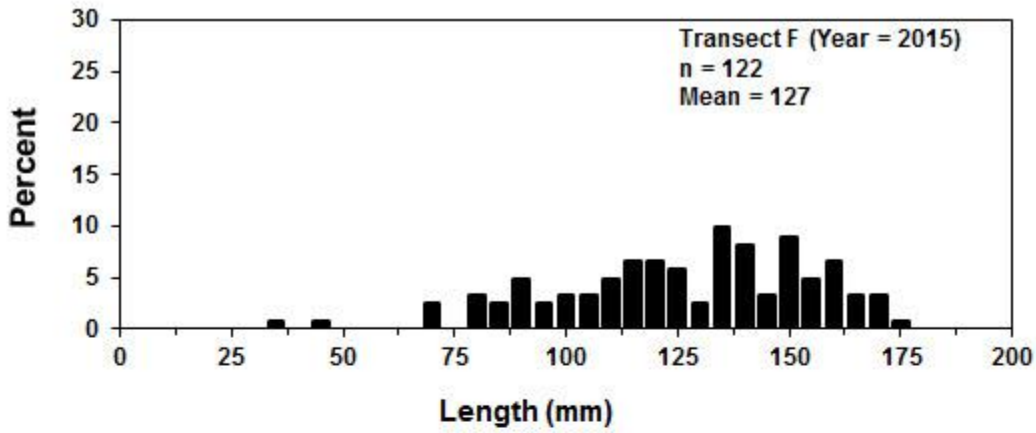
Appendix OO. (cont.)

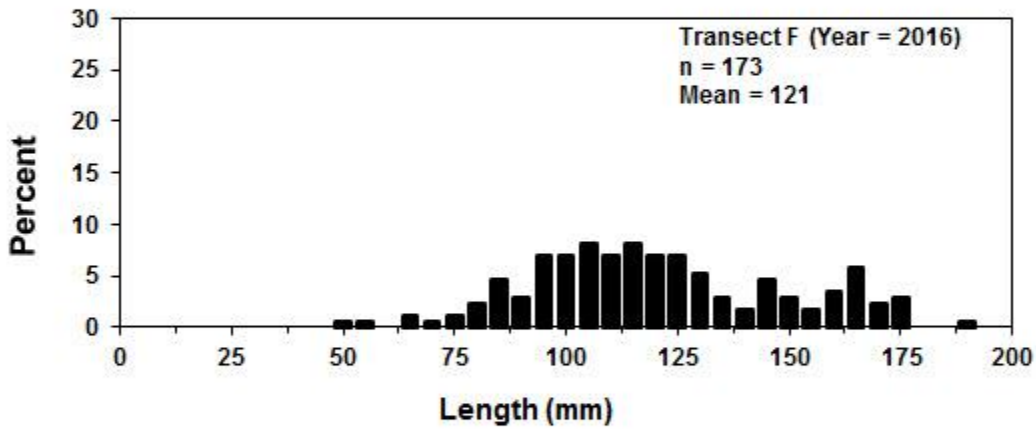


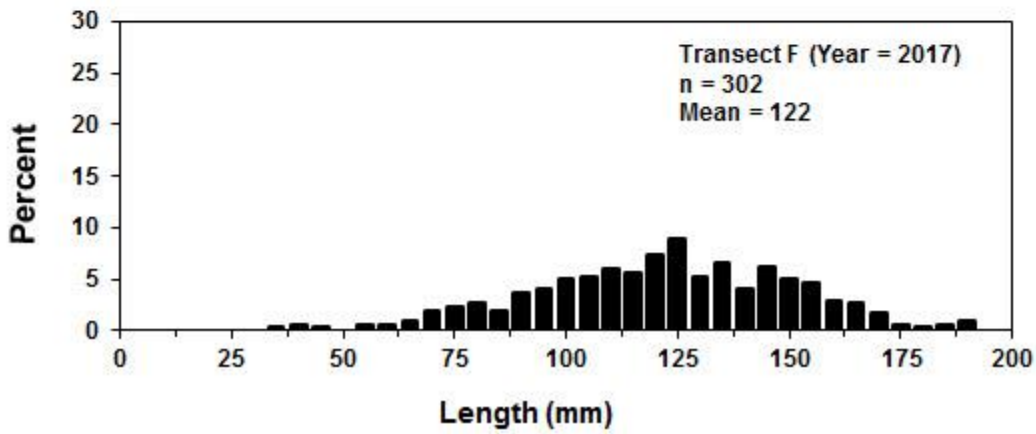




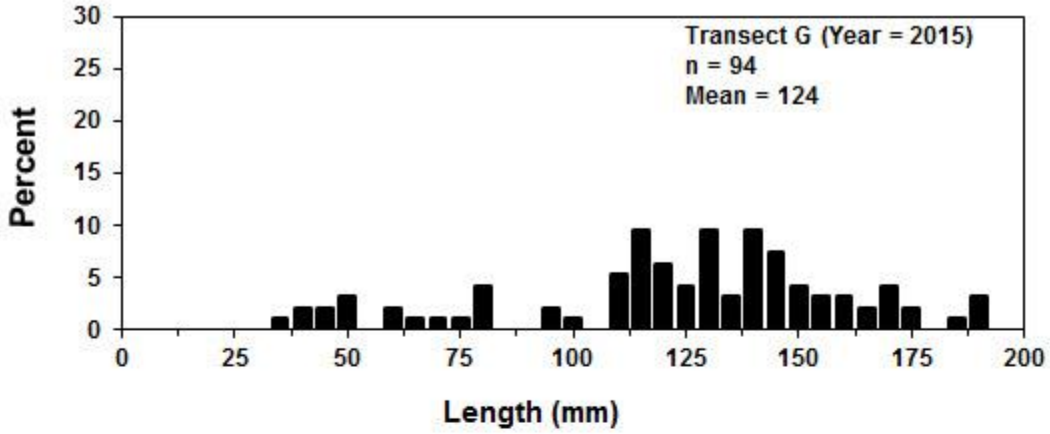
Appendix OO. (cont.)

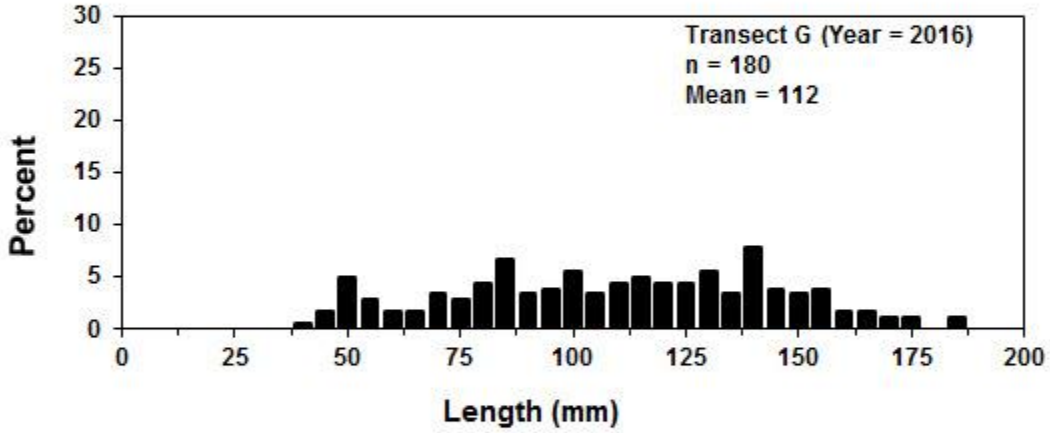


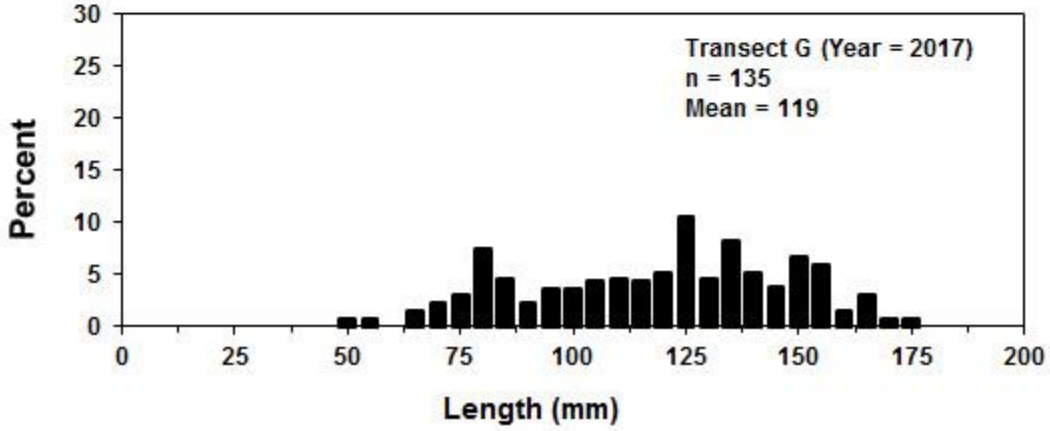




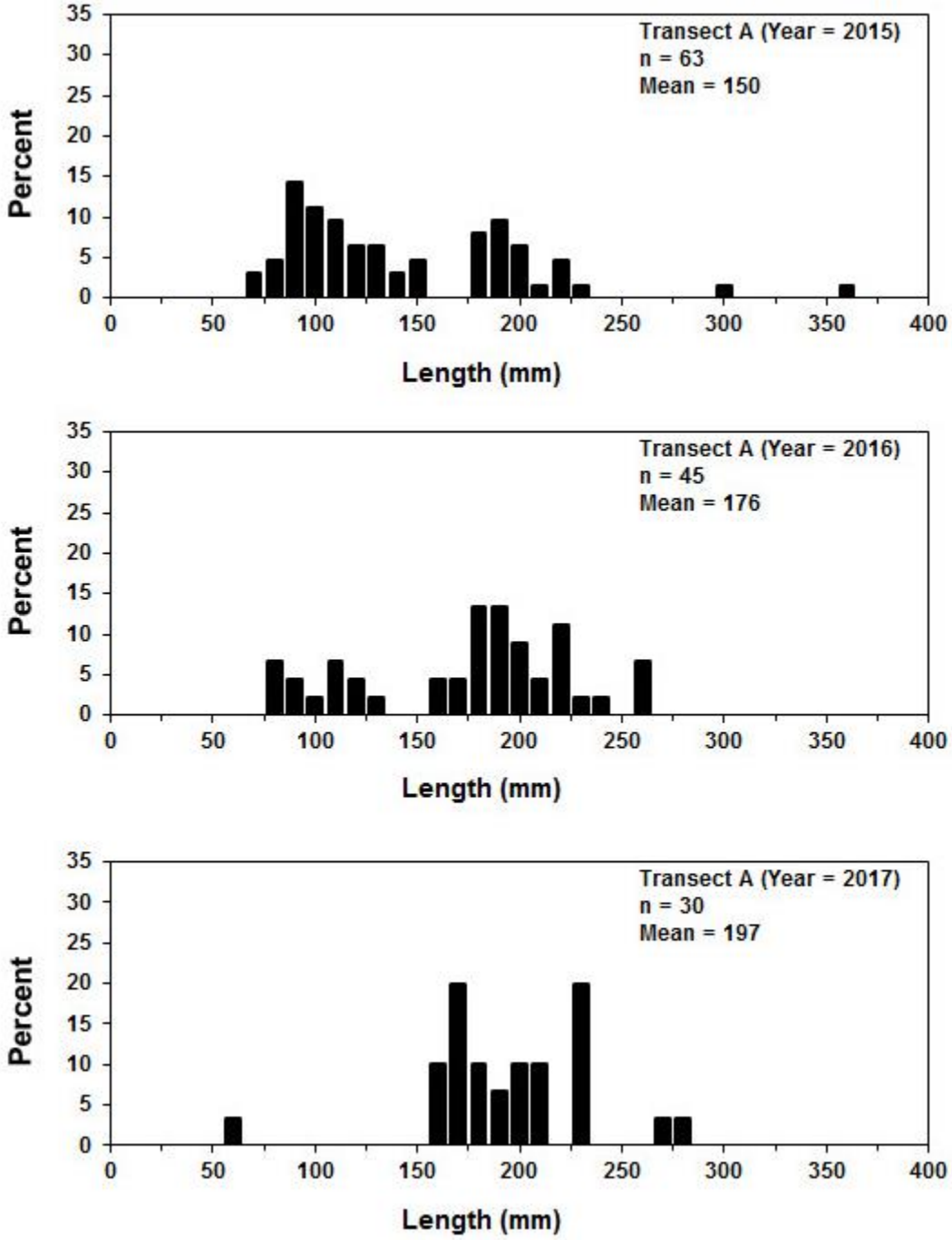
Appendix OO. (cont.)



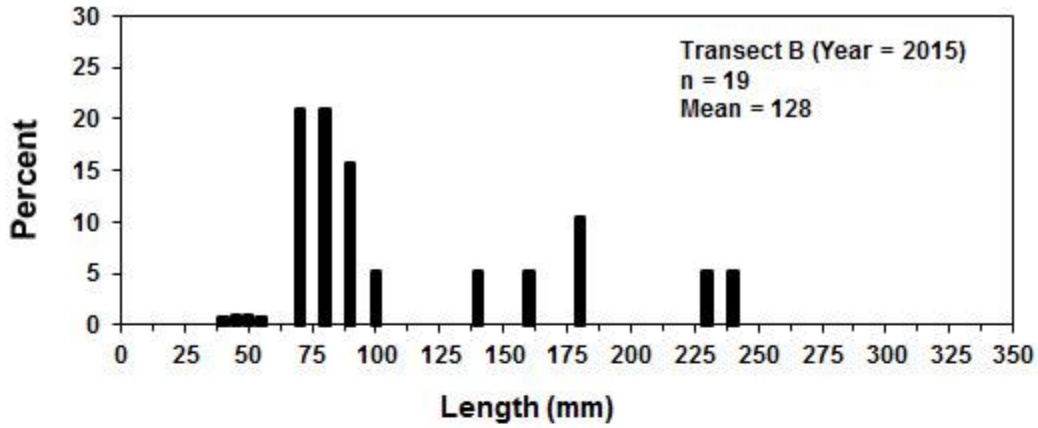


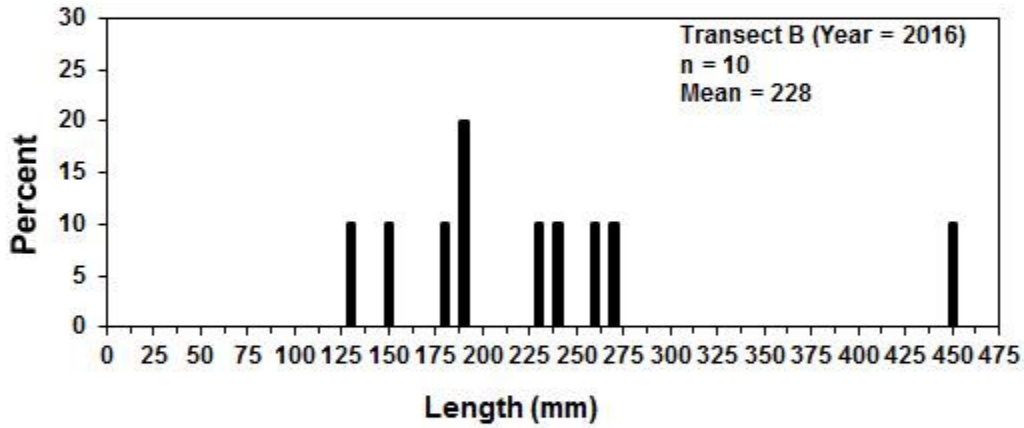


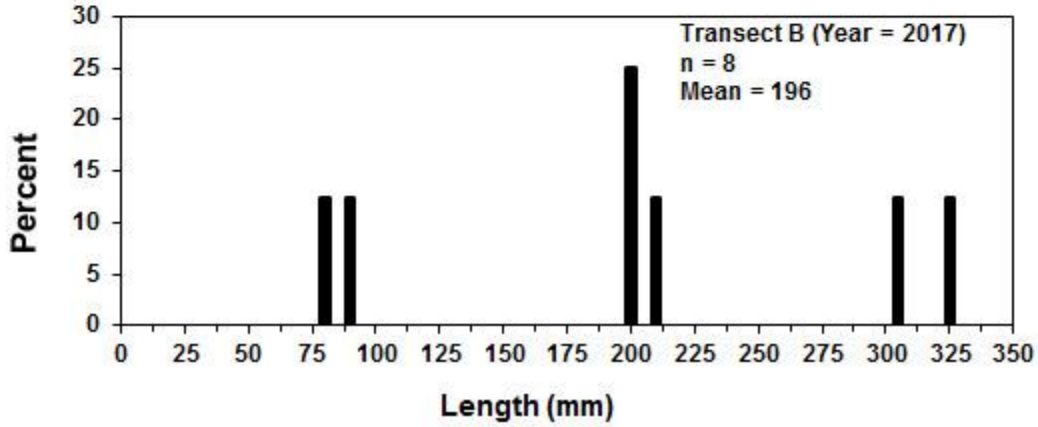
Appendix PP. Smallmouth Bass length frequency histograms from Transects A, B, D, E, and F, 2015-2017.



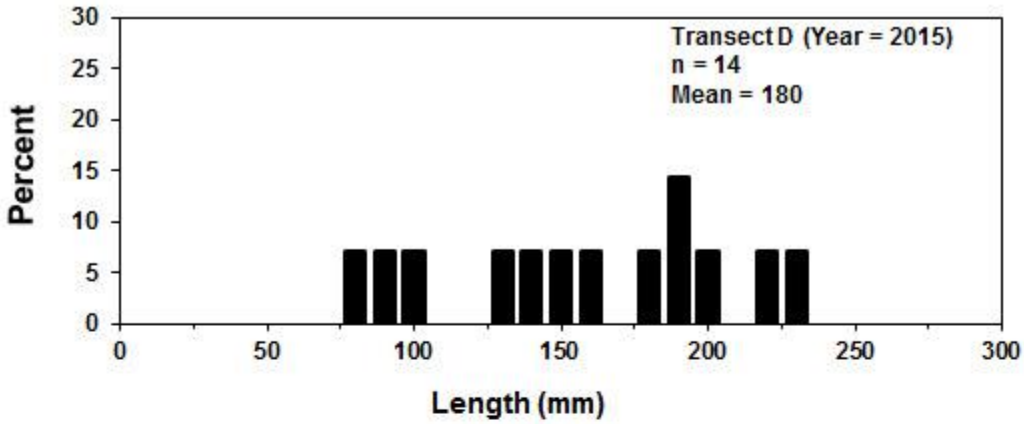
Appendix PP. (cont.)

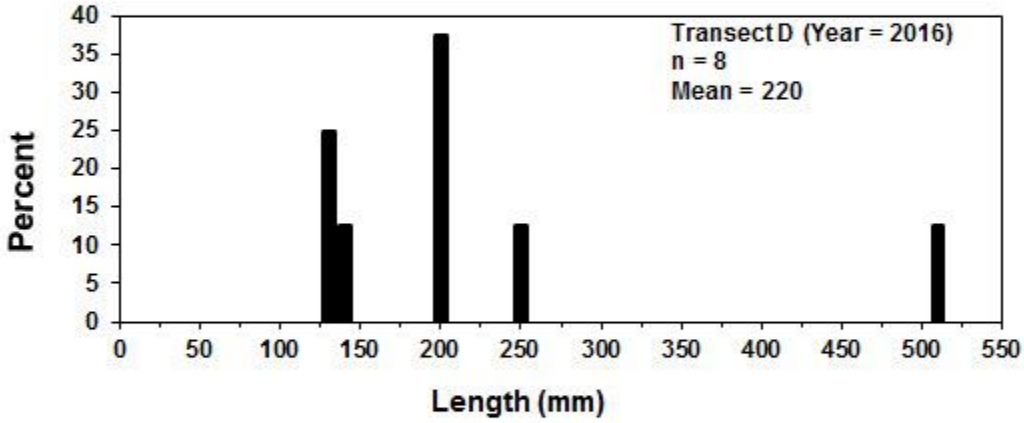


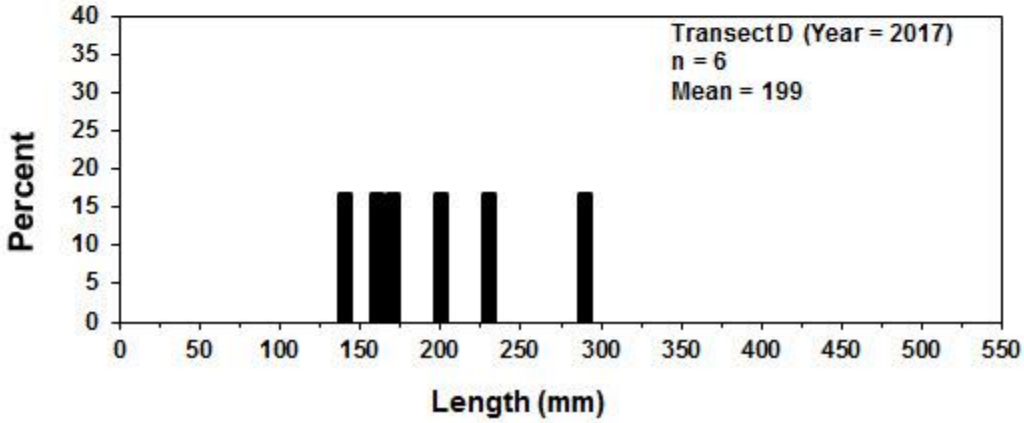




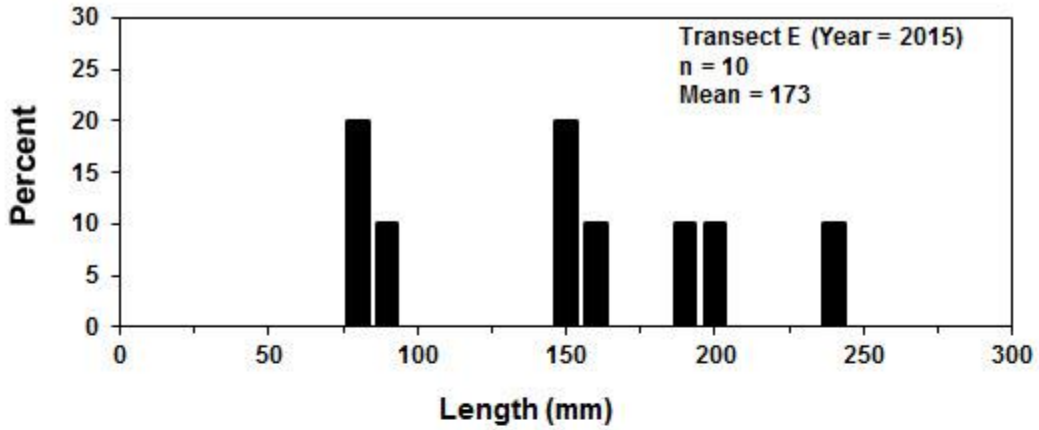
Appendix PP. (cont.)

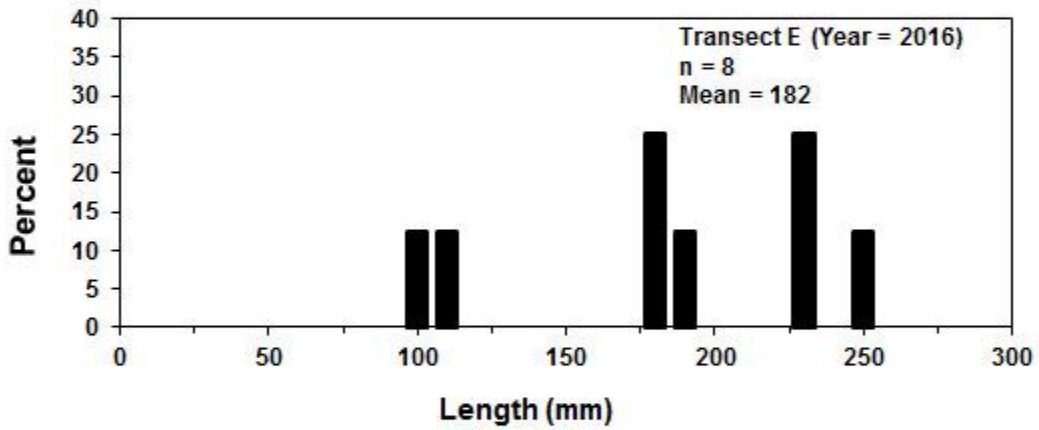


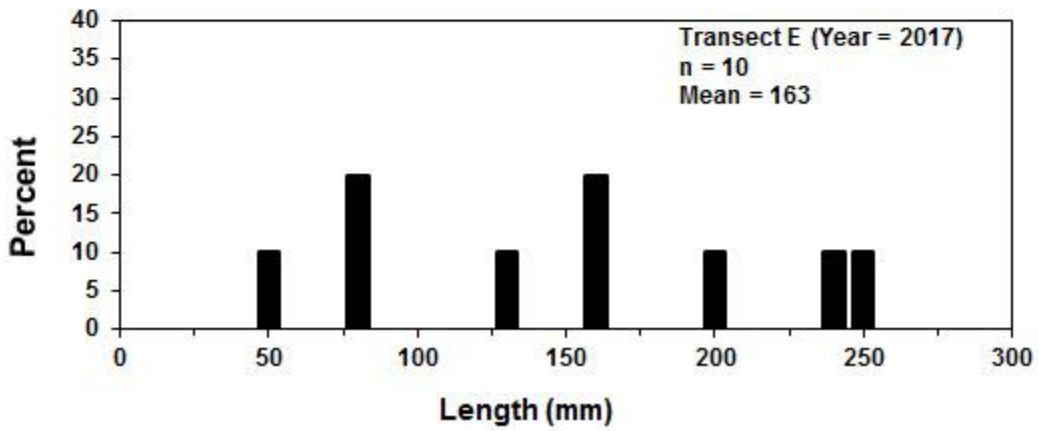




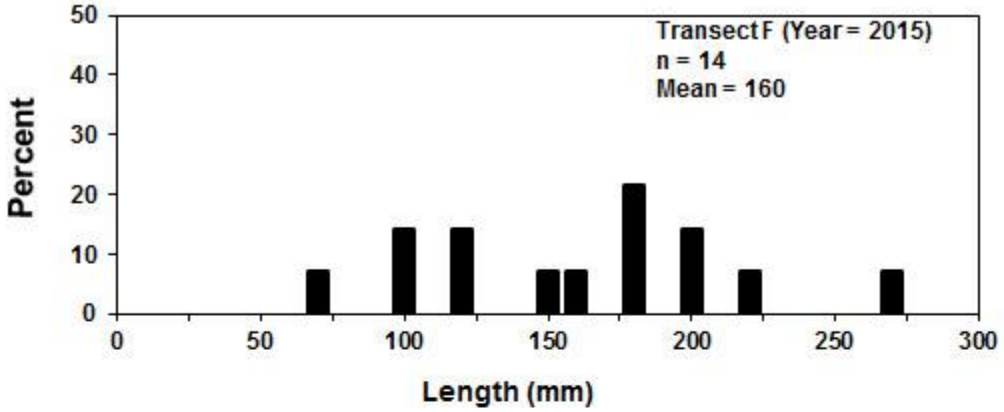
Appendix PP. (cont.)

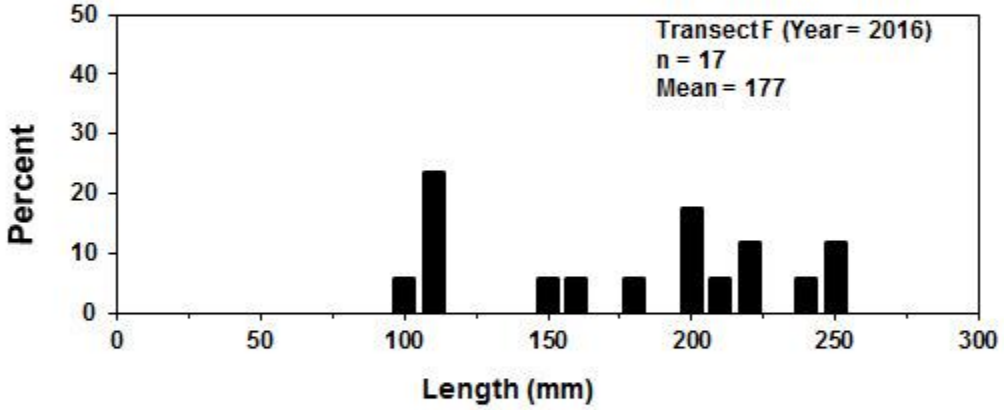


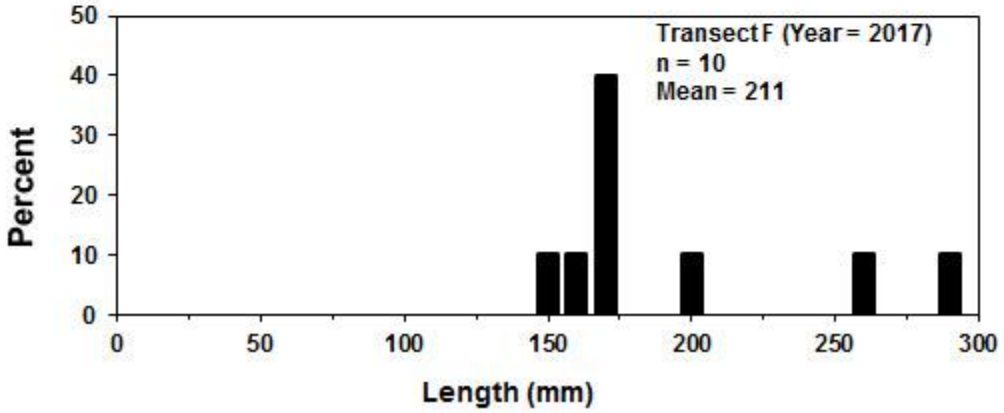




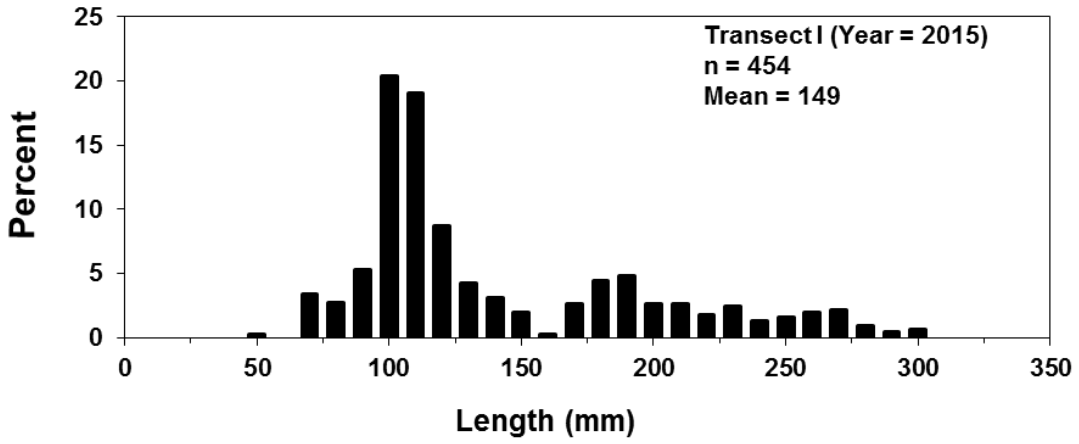
Appendix PP. (cont.)

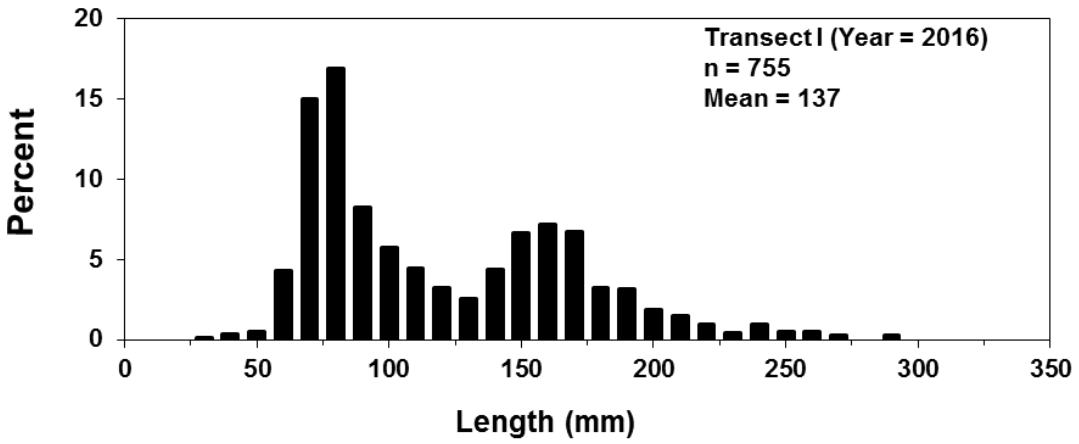


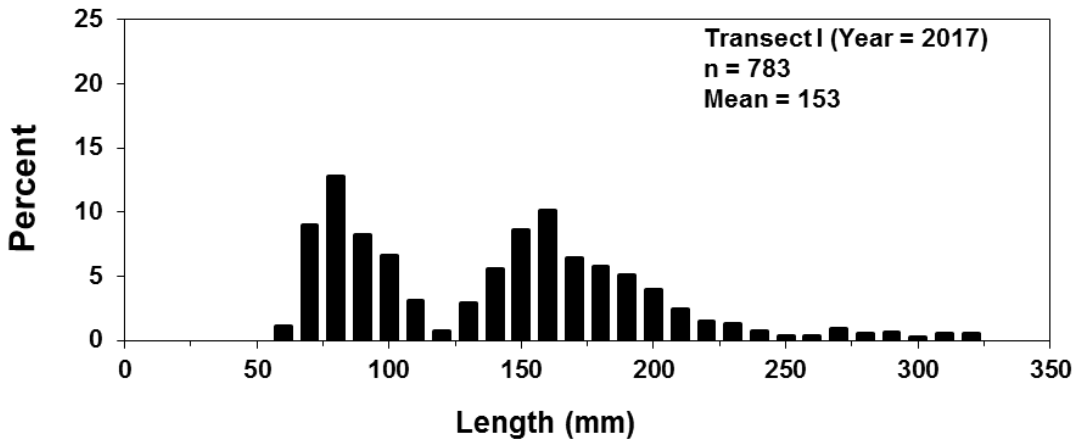




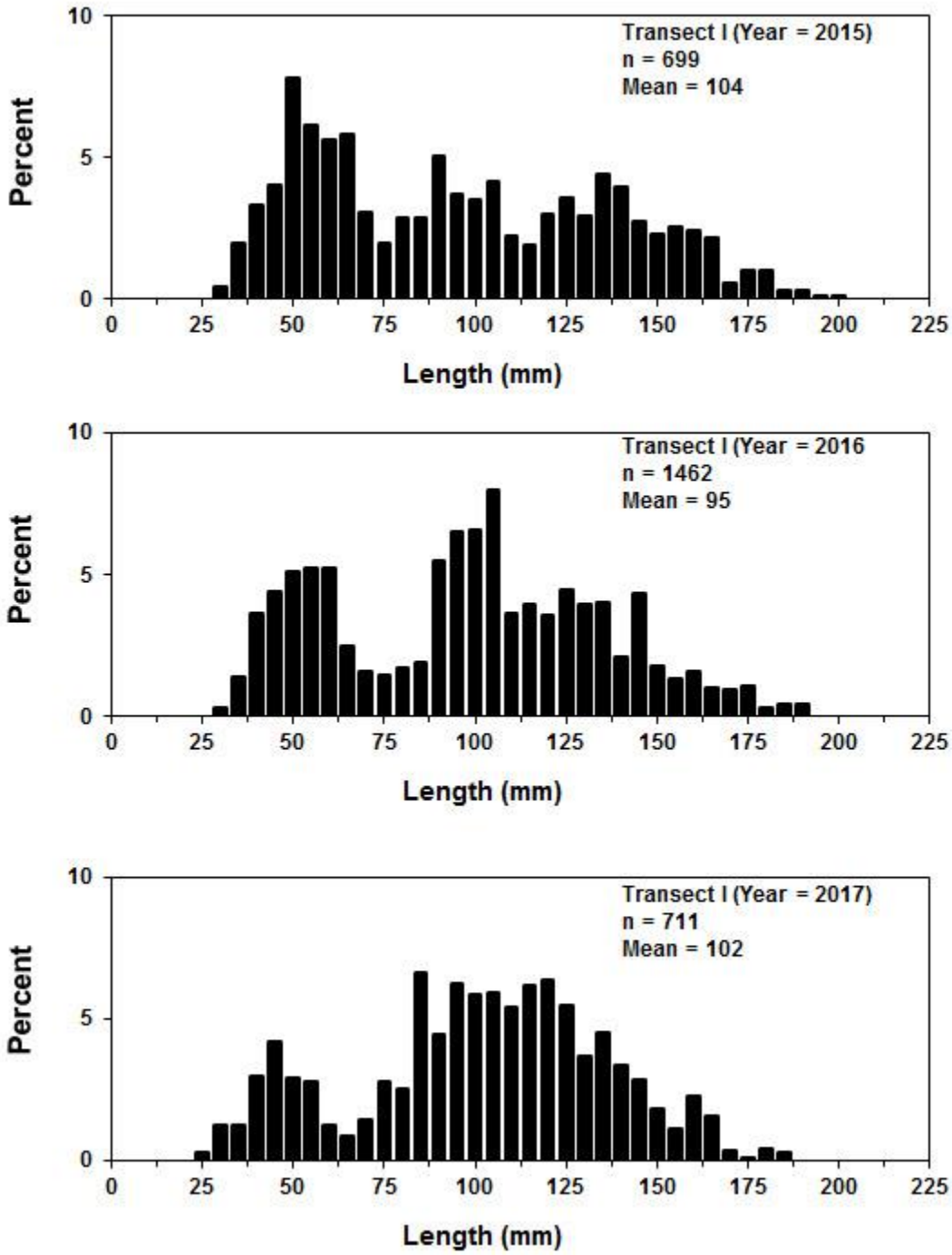
Appendix QQ. Gizzard Shad length frequency histograms from Transect I during 2015, 2016, and 2017.



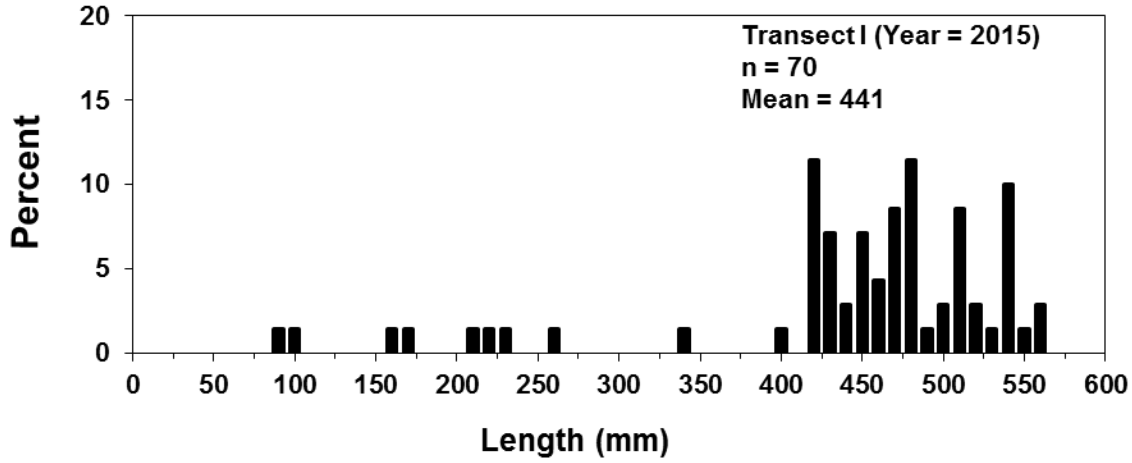


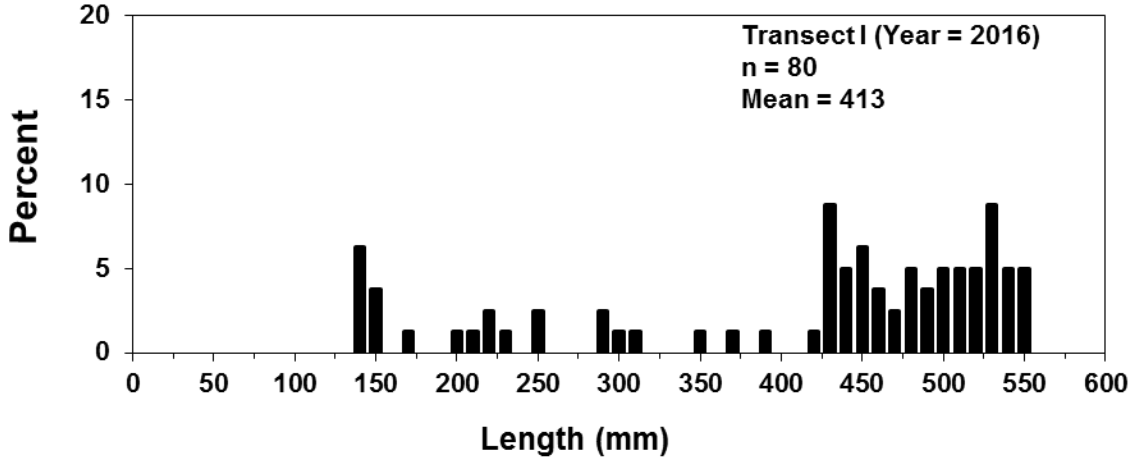


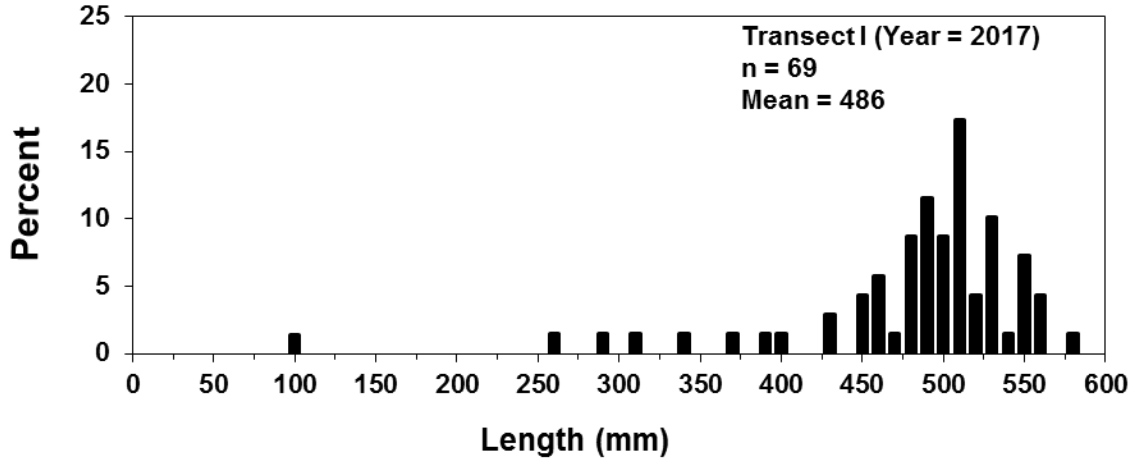
Appendix RR. Bluegill length frequency histograms from Transect I during 2015, 2016, and 2017.



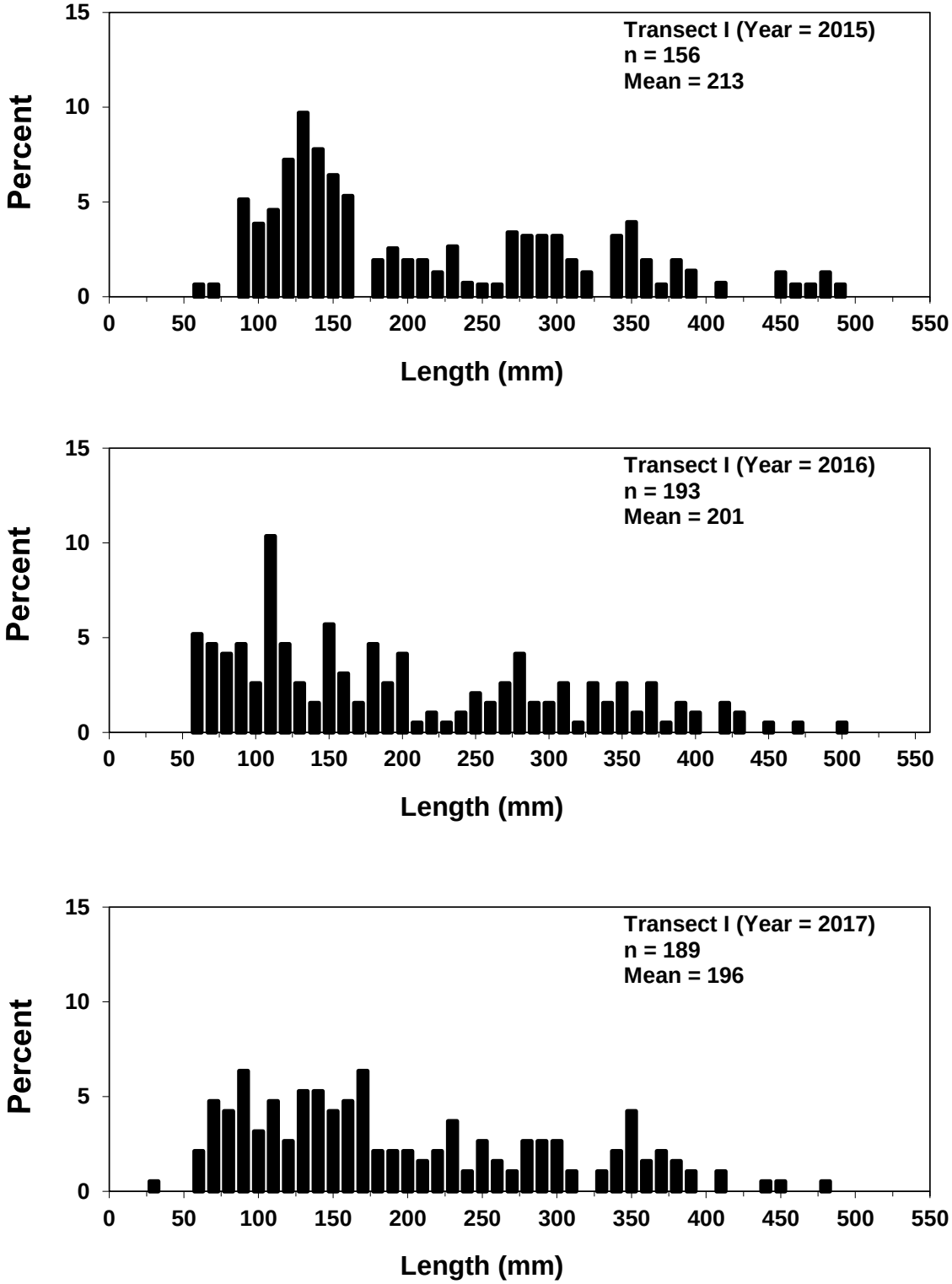
Appendix SS. Notchlip Redhorse length frequency histograms from Transect I during 2015, 2016, and 2017.



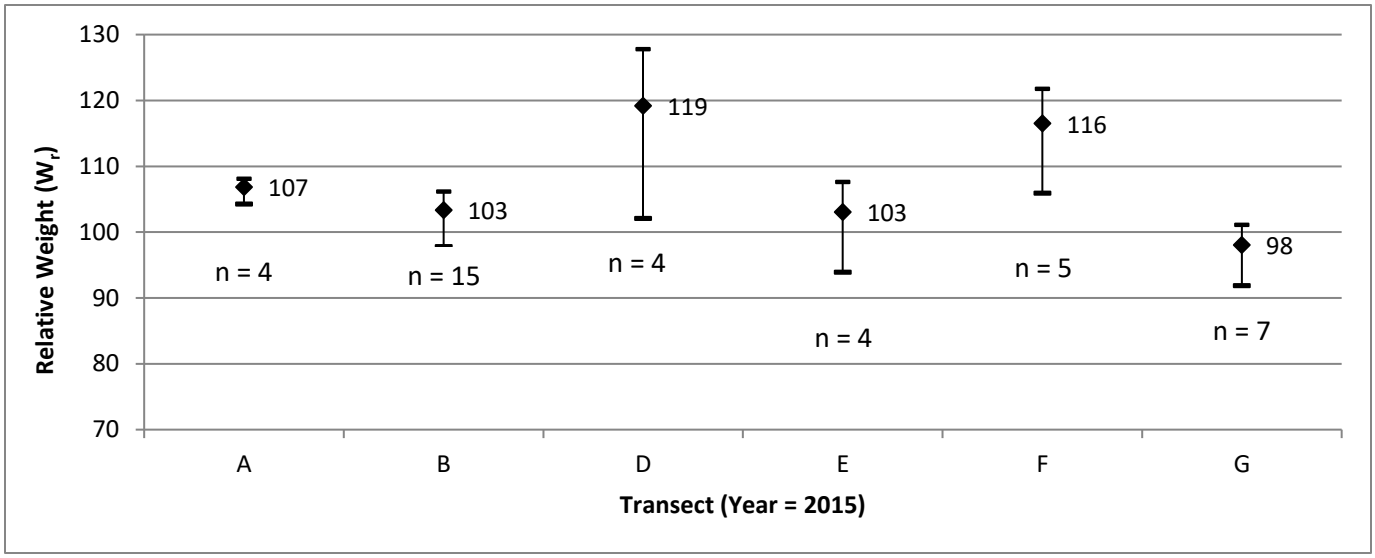


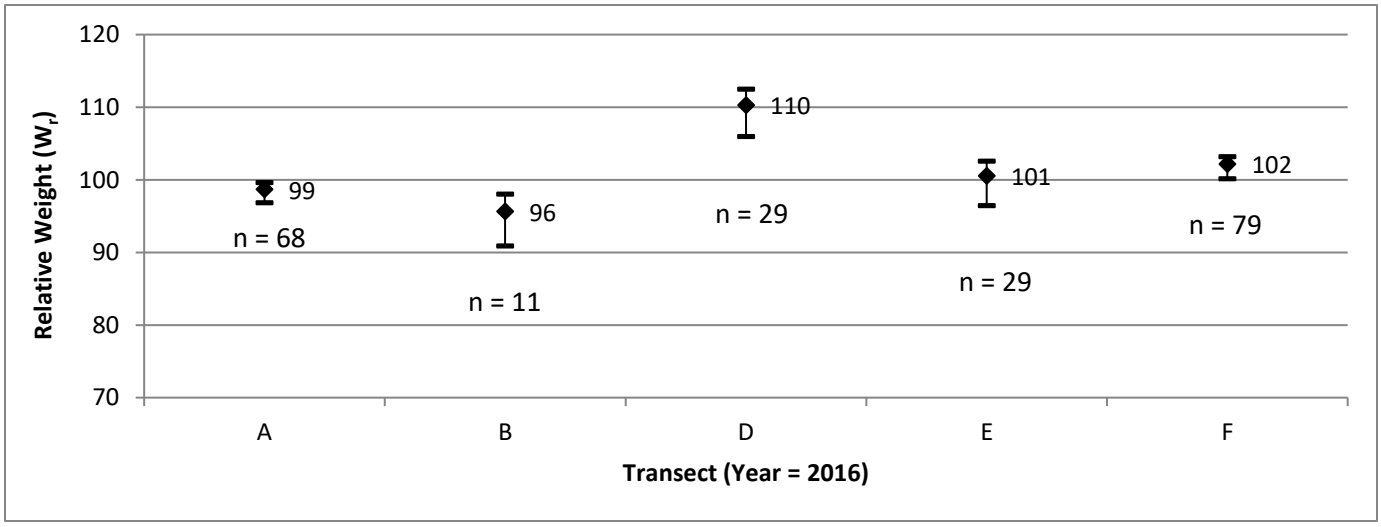


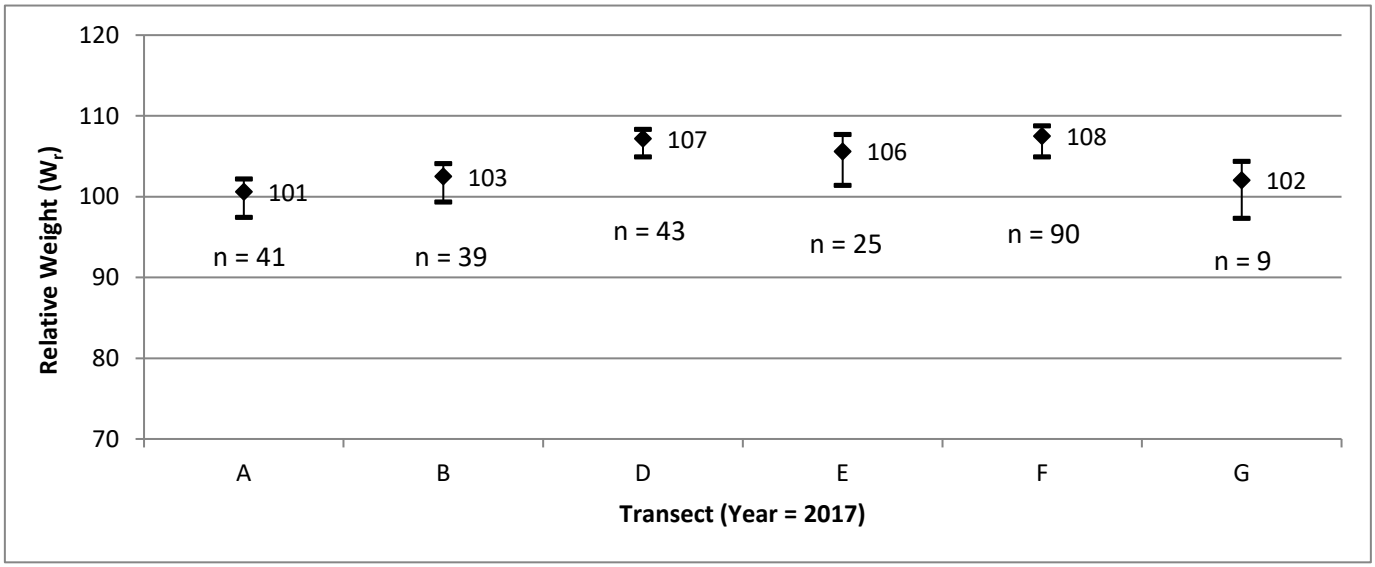
Appendix TT. Largemouth Bass length frequency histograms from Transect I during 2015, 2016, and 2017.



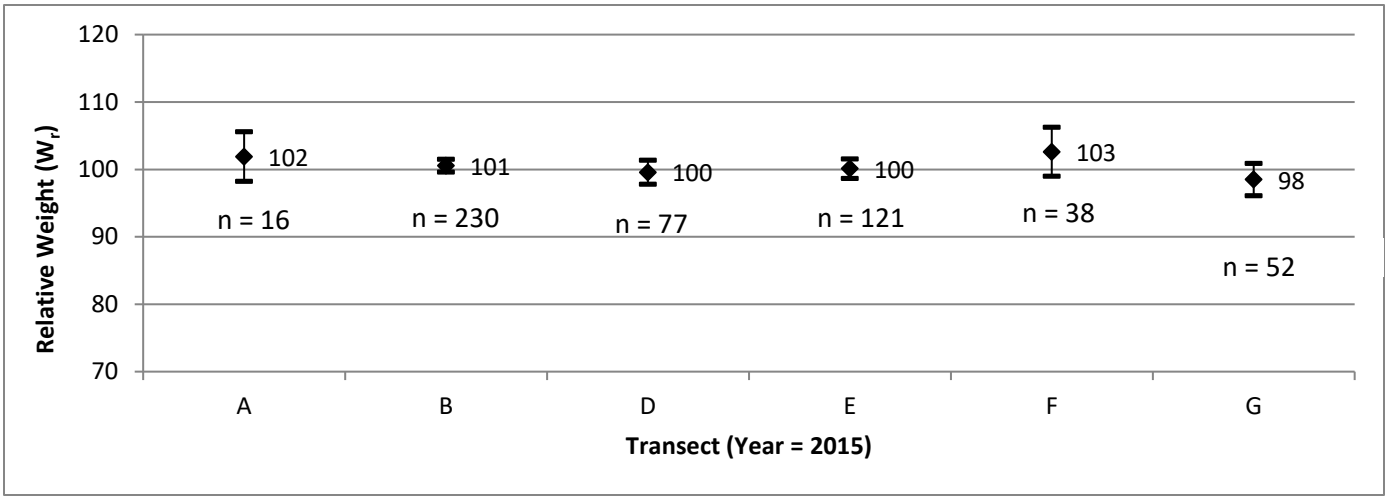
Appendix UU. Relative weight (W_r) values across sampling sites for Bull Chub during 2015, 2016, and 2017.

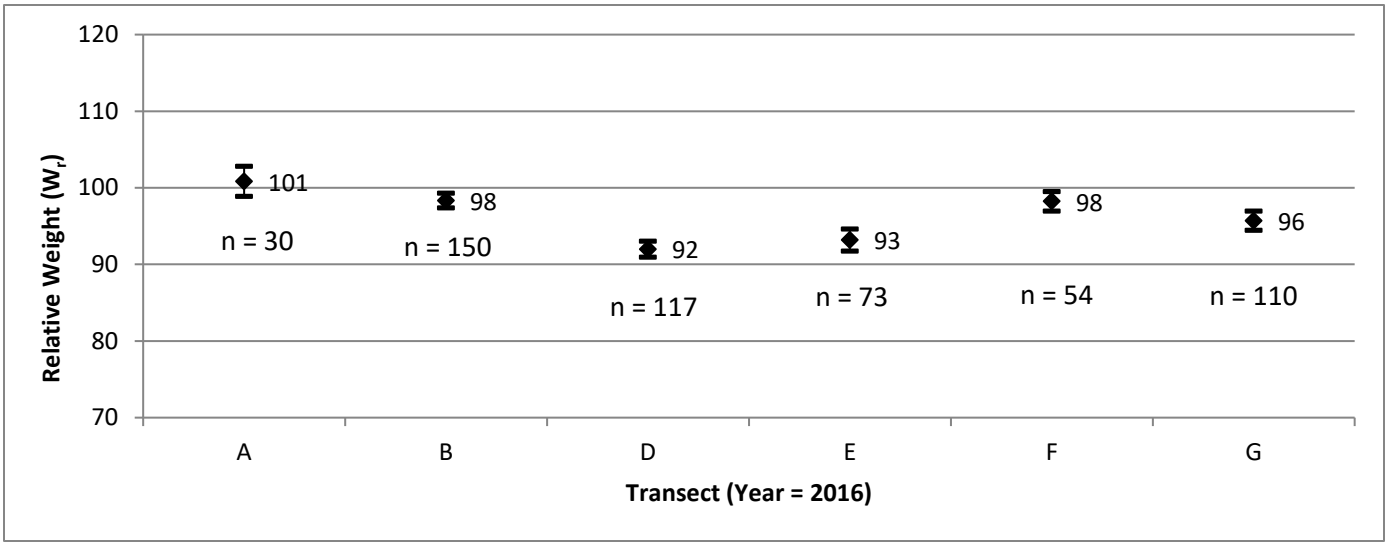


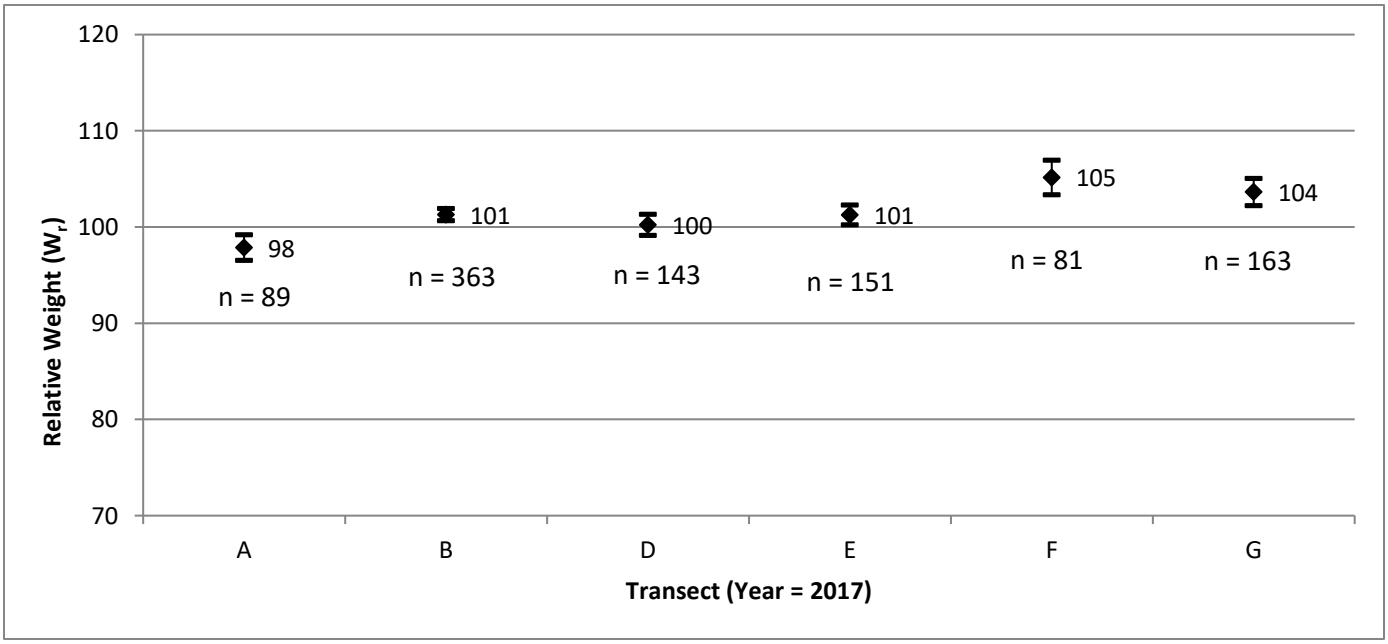




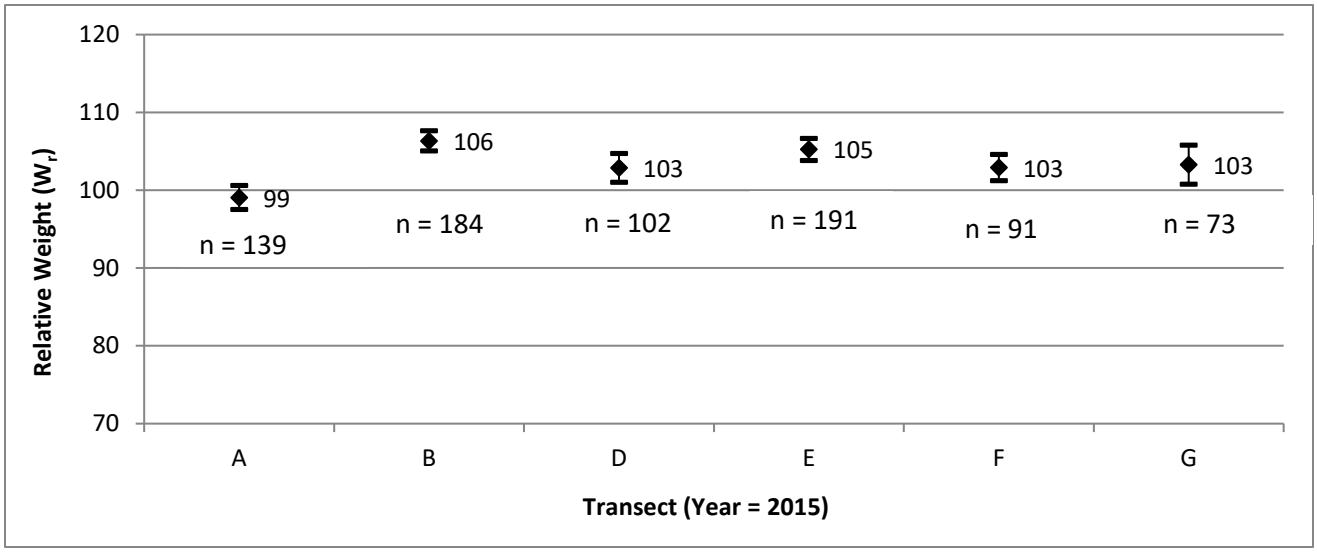
Appendix VV. Relative weight (W_r) values across sampling sites for Golden Redhorse during 2015, 2016, and 2017.

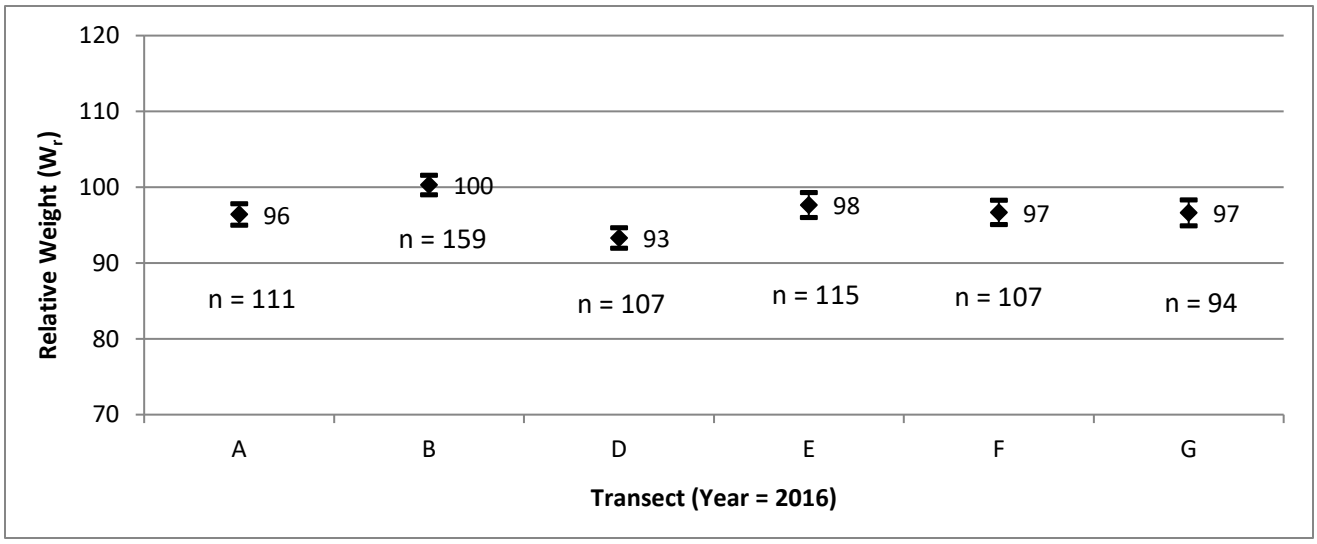


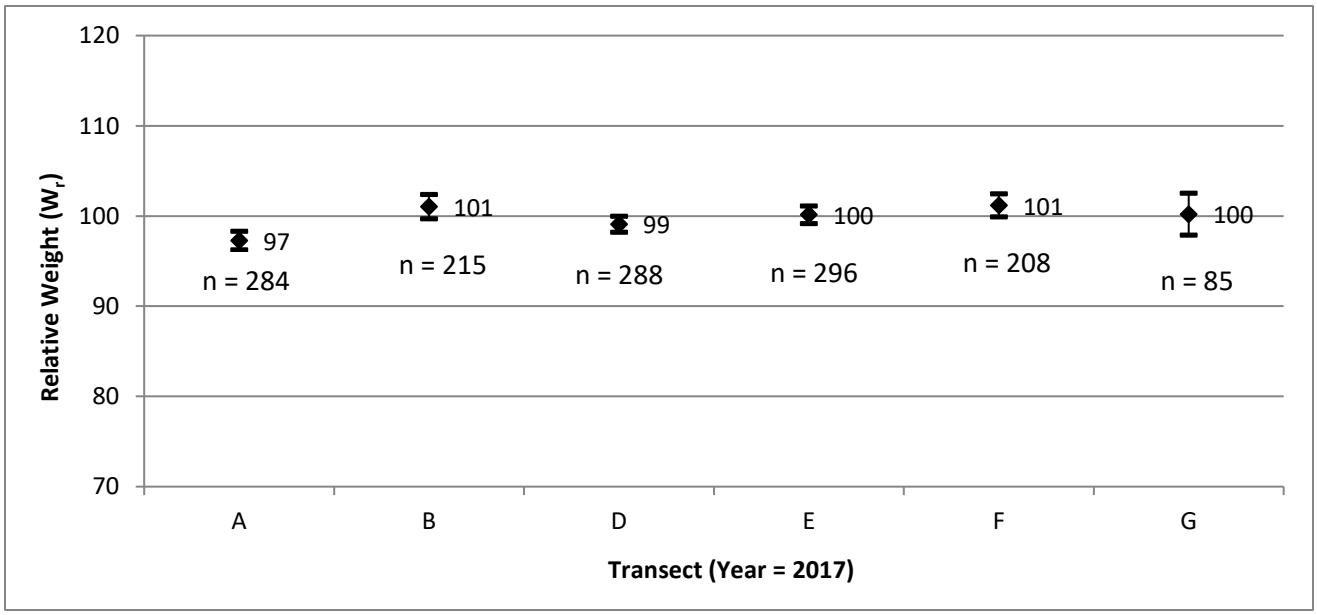




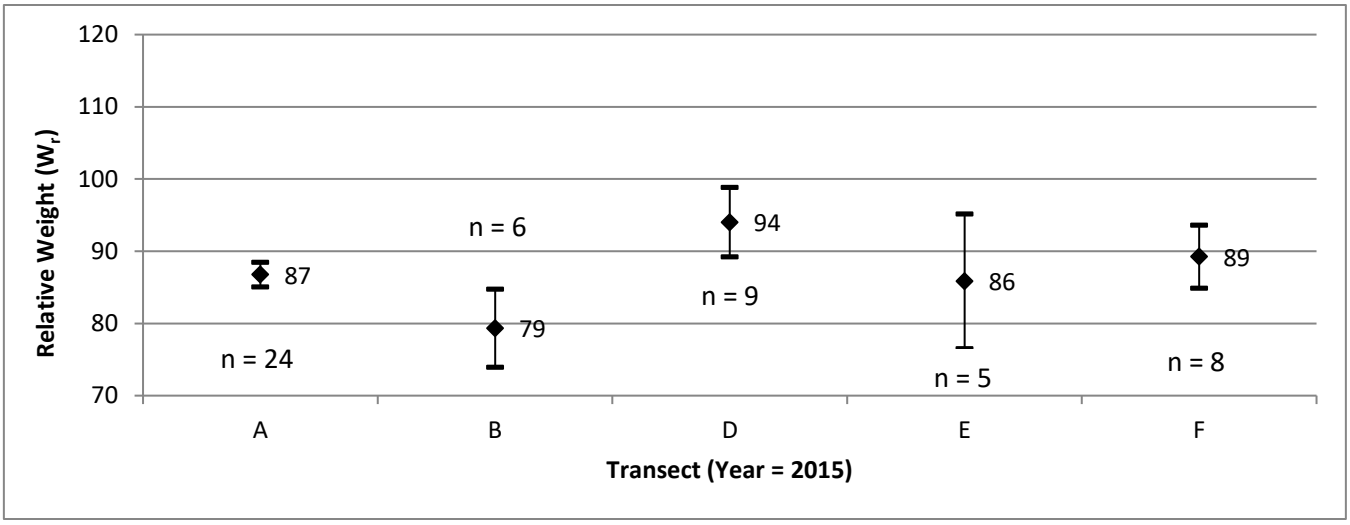
Appendix WW. Relative weight (W_r) values across sampling sites for Redbreast Sunfish during 2015, 2016, and 2017.

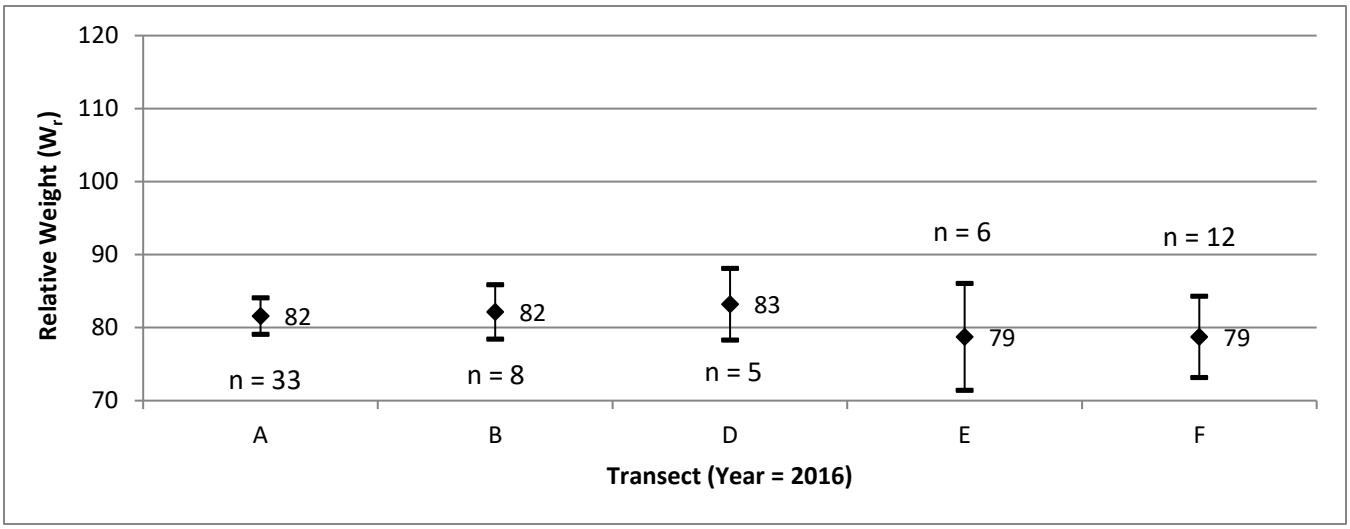


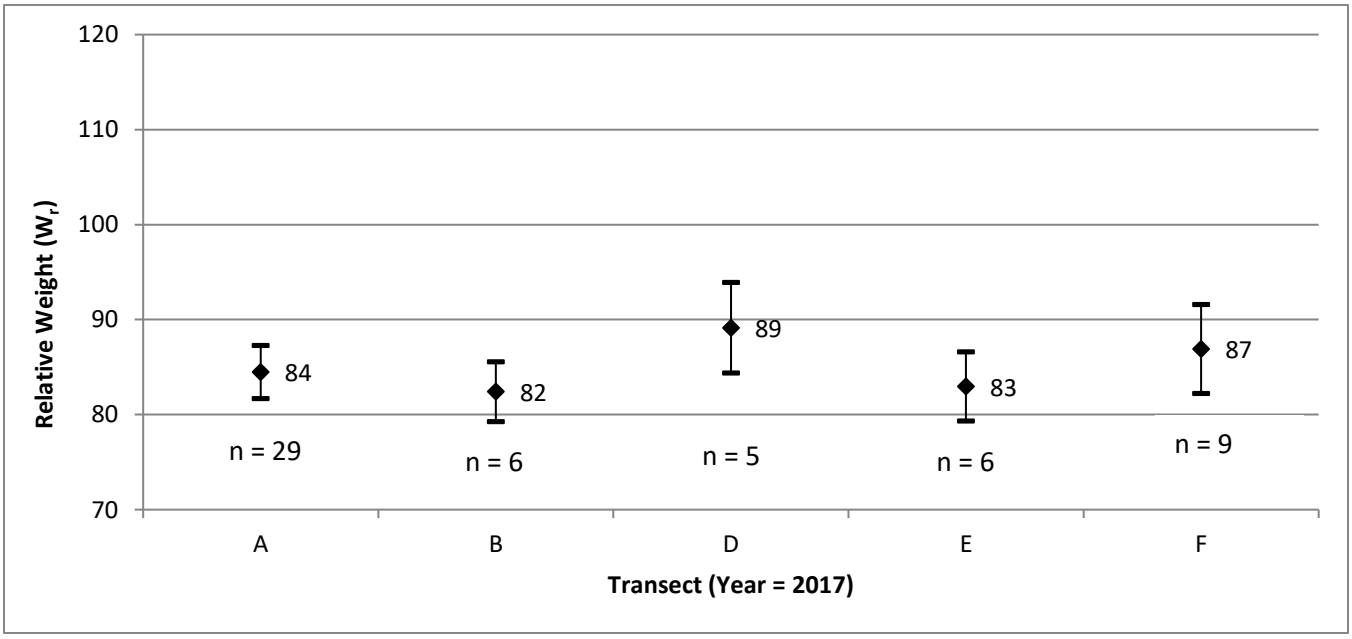




Appendix XX. Relative weight (W_r) values across sampling sites for Smallmouth Bass during 2015, 2016, and 2017.

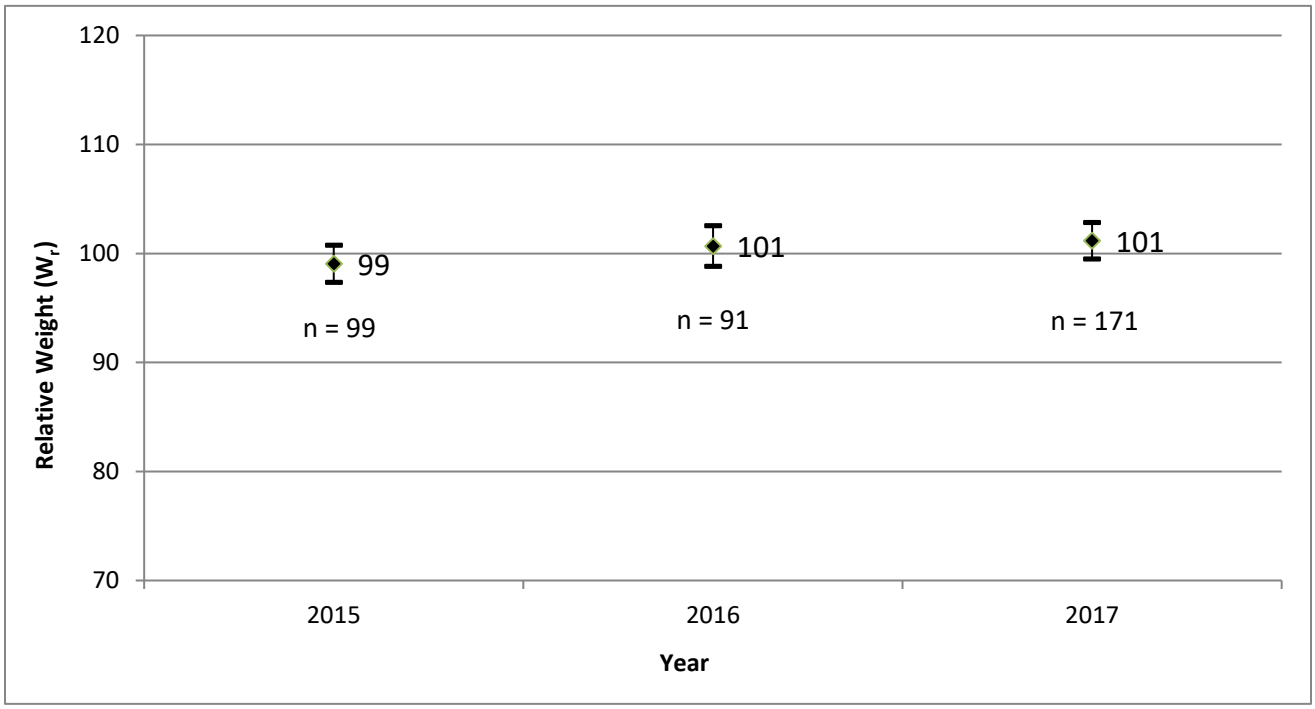






Appendix YY. Relative weight (W_r) values at Transect I for Gizzard Shad, Notchlip Redhorse, Bluegill, and Largemouth Bass during 2015, 2016, and 2017.

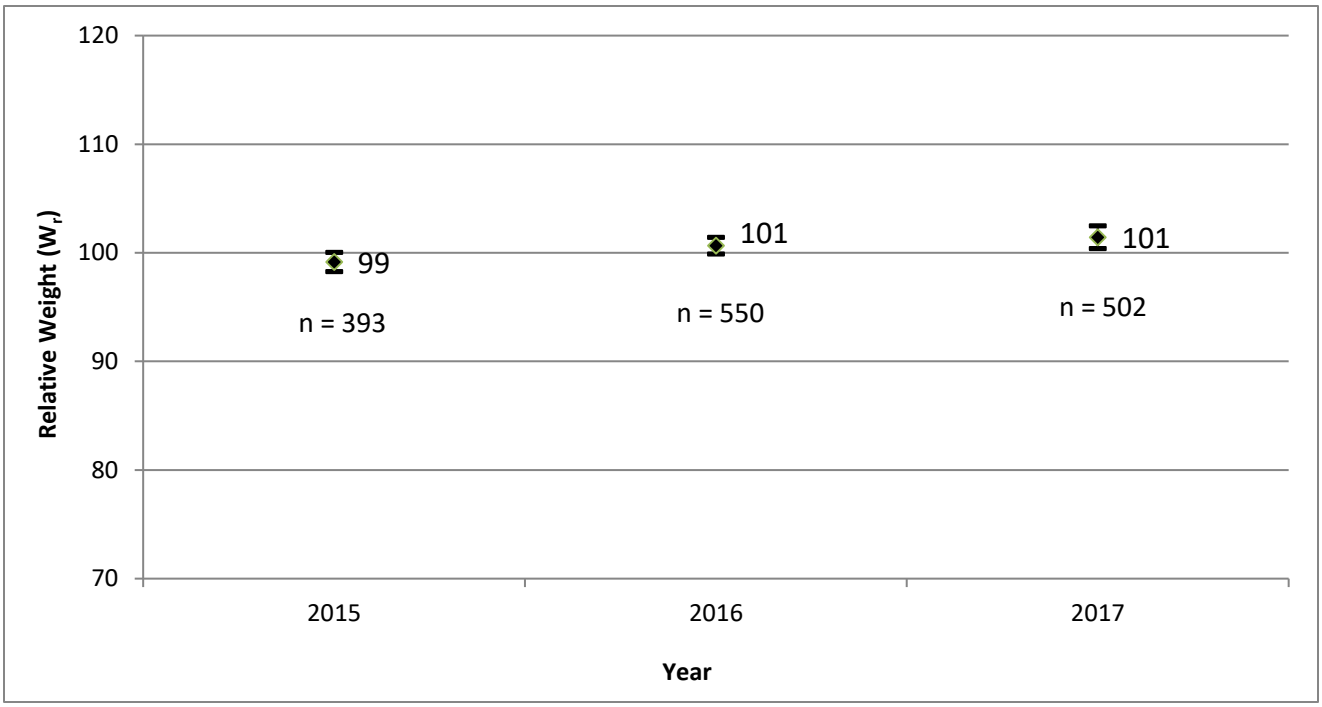
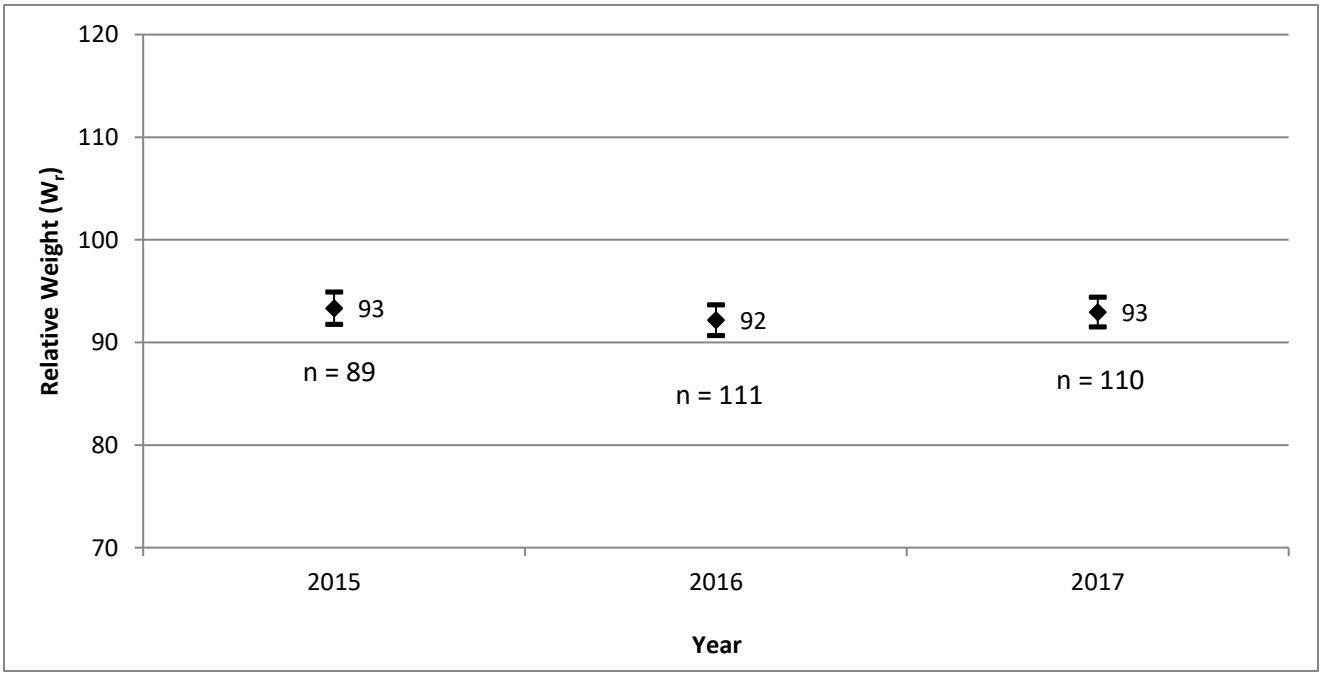
Gizzard Shad



Notchlip Redhorse

Appendix YY. (cont.)

Bluegill



Largemouth Bass