

MEMORANDUM

TO: Parr Relicensing – Fisheries Technical Working Committee

FROM: Jordan Johnson and Henry Mealing – Kleinschmidt Associates

DATE: May 30, 2017

RE: Revised Fairfield Entrainment Mortality Estimate

The Desktop Fish Entrainment Study for the Parr Hydroelectric Project (FERC No. 1894) (Project) was finalized after review by the Fisheries Technical Working Committee (TWC) on September 14, 2015. The 2015 study provided conservative estimates of potential fish entrainment and subsequent turbine mortality estimates for both the Parr and Fairfield developments based on data from other hydropower projects. Recently, the South Carolina Department of Natural Resources (SCDNR) questioned the magnitude of potential entrainment and turbine mortality at the Fairfield Development (Fairfield). They noted that additional information from the South Carolina based Jocassee Pump Storage Station (JPSS) (Keowee-Toxaway Hydropower Project FERC No. 2503) was also available for use in our analysis. The “new” JPSS information is primarily related to turbine mortality rates at pump back hydropower facilities, therefore, we used the information to re-evaluate the turbine mortality estimates for Fairfield. No new information is currently available to address the density of fish in the forebay or tailrace of Fairfield that could alter the potential magnitude of fish entrainment.

BACKGROUND

As part of a fish community assessment study of the JPSS, Duke Energy (Duke) conducted hydroacoustic sampling to estimate fish entrainment and a desktop analysis to estimate turbine mortality at JPSS (Duke 2013). The mortality analysis was based on primary factors that influence fish mortality during entrainment: turbine type, turbine speed (rpm), pressurized intake tunnel, and fish size. The analysis noted that, after review of Winchell et al. (2000) which summarized turbine passage mortality reported in the EPRI (1997) database, “the data suggest that fish size relative to the volume of the turbine passage way is more important than species

per se when assessing fish survival potential (Franke et al. 1997, Winchell et al. 2000).” The JPSS analysis used the formula developed by Franke et al. (1997) to predict mortality, i.e. the probability of a fish strike, for fish passing through a Francis turbine. The formula calculated the probability of a blade strike by relating turbine parameters to fish length. Calculations showed that fish from two inches to 24 inches survive entrainment at a rate of approximately 99% to 88% at JPSS. Basically, shorter fish maintain a higher survival percentage than longer fish. The analysis also noted that, after comparison to data at similar projects, mortality related to decompression was expected to be low at JPSS.

METHODS

To update our analysis, we performed two steps. First, calculate the blade strike probabilities for each length class of fish up to 30 inches using the JPSS equation and the Fairfield turbine specifications. Second, generate a breakdown of length classes for each family group we presented in our 2015 report.

The first step for calculating blade strike probability was based on the formula developed by Franke et al. (1997).

$$P = \lambda \left(\frac{N * L}{D} \right) \left[\frac{\sin \alpha_t \left(\frac{B}{D_1} \right)}{2Q_{\text{cfd}}} + \frac{\cos \alpha_t}{\pi} \right]$$

S = 1 – P where,

λ = Blade strike correlation factor

N = Number of buckets

L = Fish length

D = Diameter of runner

α_t = Angle to tangential of absolute flow upstream of runner

B = Runner height at inlet

D₁ = Diameter of runner at inlet

Q_{cfd} = Discharge coefficient = (Q/ωD³)

Blade strike probabilities were calculated using a blade strike correlation factor of 0.15. This factor was chosen because it gave a higher, more conservative mortality rate. Table 1 contains the turbine parameters at Fairfield assuming the plant is operating at the best efficiency point for both generation and pumping.

TABLE 1. FAIRFIELD FRANCIS TURBINE SPECIFICATIONS

TURBINE CHARACTERISTICS		GENERATION	PUMPING
Turbine Type		Francis reversible pump	
No. of Buckets		9	
Runner Diameter (ft.)	inlet	15.92	15.42
	outlet	15.42	15.92
Runner Height at inlet (ft.)		5.43	
RPM		150	
Head (ft.)		160	163
Hydraulic Capacity (cfs)		6,130	4,920

The second step was the development of a database of seasonal fish length class percentages for the Family groups of fish potentially entrained at the Project presented in our 2015 report. The database developed consisted of seasonally entrained species and length class data found within the EPRI (1997) database. Data from the EPRI database that were not relevant were screened to form a Project specific database. The data selected to form the database consisted of studies conducted at Gaston Shoals, Hollidays Bridge, Ninety-Nine Islands, Richard B. Russell (RBR), and Saluda. These hydroelectric projects were also used in other portions of the 2015 Parr/Fairfield entrainment study. These projects were chosen for the development of the dataset for several reasons. All the projects are located within South Carolina and contain similar fish communities as that found at Parr/Fairfield. Also, combining the data from each of the studies provided the most comprehensive database of seasonal length class data for fish potentially entrained at Fairfield.

The seasonal species and length class data for each of the five projects were combined to form length class percentages for the fish Family groups previously identified for Fairfield. This exercise was similar to the development of “species composition percentages” in our 2015 report. If no data existed for certain family groups or months, surrogates were designated. The fish length classes were separated into two-inch increments with a minimum fish length of two inches and a maximum fish length of 30 inches.

Once seasonal length class percentages for each family group were calculated, the length class percentages were multiplied by the seasonal total entrainment number for each family from our original report. This divided the total estimated fish entrained at Fairfield into length classes for each family.

Once an estimate of fish potentially entrained within each length class was calculated, Fairfield blade strike probabilities (i.e., mortality rate) for each of the length classes were multiplied by the estimated number of fish entrained within that length class. This resulted in a seasonal estimate of fish killed due to entrainment at Fairfield for each family group and length class. The mortality rate for the longest fish within each length class was applied (e.g., the mortality rate for a 6-inch fish was used for all fish within the 4-6” length class).

RESULTS

Turbine mortality rates ranged from 1.7% to 25.8% for fish entrained during conventional generation and from 1.8% to 27.7% for pump back generation (Table 2). This method of estimating fish mortality predicted far fewer fish being killed by turbine blade strikes at Fairfield than the 2015 report. The updated method predicts reduced mortality at the project across all families when compared to estimates from the 2015 report (Table 3).

The database used to develop length class percentages is provided in Appendix A. Seasonal length class percentages are provided in Appendix B. Entrainment estimates from the 2015 Fairfield study are provided in Appendix C. Updated family entrainment and mortality estimates by length class are provided in Appendix D.

TABLE 2. BLADE STRIKE PROBABILITIES

LENGTH (IN)	CONVENTIONAL	PUMPING
2	1.7%	1.8%
4	3.4%	3.7%
6	5.2%	5.5%
8	6.9%	7.4%
10	8.6%	9.2%
15	12.9%	13.8%
20	17.2%	18.5%
25	21.5%	23.1%
30	25.8%	27.7%

TABLE 3. COMPARISON OF FISH MORTALITY BETWEEN 2015 PARR ENTRAINMENT REPORT AND 2017 TURBINE MORTALITY ANALYSIS

	2017 ANALYSIS ANNUAL ESTIMATE		2015 STUDY ANNUAL ESTIMATE	
	CONVENTIONAL	PUMPBACK	CONVENTIONAL	PUMPBACK
Clupeidae	32,048	105,495	74,589	276,777
Moronidae	484	4,081	3,318	27,581
Black Bass	15	633	59	3,485
Panfish	1,006	2,019	8,148	16,399
Ictaluridae	2,714	1,028	15,468	6,073
Percidae	5,681	472	36,865	3,110
Cyprinidae	201	594	597	1,742
Fundulidae	0	16	0	38
Esocidae	0	5	0	8
Catostomidae	10	5	36	20
Lepisosteidae	2	2	4	3
SUB-TOTAL	42,161	114,351	139,084	335,236
TOTAL	156,512		474,320	

DISCUSSION

Based on the new turbine mortality information, the estimated fish mortality presented in the 2015 Report would be reduced by 67% (Table 3). That is a significant reduction in the number of fish that are potentially killed by passing through the turbines.

No new fish density information for the Fairfield forebay or tailrace areas is currently available that could be used to address the magnitude of fish entrainment. During discussions with TWC members, several ideas have been identified for reducing the potential for fish entrainment. Reduction of area lighting along the intake areas, which may attract fish at night, was proposed as a potential way to reduce concentrations of fish adjacent to the intakes, thereby reducing fish entrainment. The effectiveness of this action could be evaluated with mobile acoustic sonar surveys in the intake areas with “lights on” and “lights off”. There was also a discussion of performing additional hydroacoustic collections in the intake areas of Fairfield – forebay and tailrace to determine actual seasonal densities of fish. This would allow for comparison of entrainment estimates with density estimates to increase the accuracy of the 2015 fish entrainment report.

We appreciate the SCDNR bringing this new information to our notice and recommend that the Fisheries TWC consider this reduction in turbine mortality and the two potential *in situ* studies when developing recommendations for protection, mitigation, and enhancement measures for the new operating license.

LITERATURE CITED

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EPRI. 1997. Turbine entrainment and survival database – field tests. Prepared by Alden Research Laboratory, Inc. EPRI Report No. 108630. 13 pp, Palo Alto, CA.

Franke, G.F., D.R. Webb, R.K. Fisher, Jr., D. Mathur, P.N. Hopping, P.A. March, M.R. Headrick, I.T. Laczó, Y. Ventikos, and F. Sotiropoulos. 1997. Development of environmentally advanced hydropower turbine system design concepts. Prepared for U.S. Dept. Energy, Idaho Operations Office. Contract DE-AC07-94ID13223.

APPENDIX A
STUDY DATABASE

STUDY DATABASE

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
2	Bluegill	Panfishes	7	1	1	1	0	0	0	0	0	0	10
2	Bluehead chub	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
2	Central stoneroller	Cyprinidae	0	0	0	1	0	0	0	0	0	0	1
2	Channel catfish	Ictaluridae	0	1	2	27	27	4	0	0	0	0	61
2	Creek chubsucker	Catostomidae	0	0	0	0	1	0	0	0	0	0	1
2	Eastern silvery minnow	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
2	Gizzard shad	Clupeidae	0	3	1	5	1	2	0	0	0	0	12
2	Golden shiner	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
2	Hybrid sunfish	Panfishes	2	0	0	0	0	0	0	0	0	0	2
2	Largemouth bass	Black Bass	0	1	0	0	0	0	0	0	0	0	1
2	Northern hog sucker	Catostomidae	0	0	0	1	0	1	0	0	0	0	2
2	Redbreast sunfish	Panfishes	1	0	0	0	0	0	0	0	0	0	1
2	Redear sunfish	Panfishes	0	1	0	0	0	0	0	0	0	0	1
2	Sandbar shiner	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
2	Seagreen darter	Percidae	0	1	0	0	0	0	0	0	0	0	1
2	Shorthead redhorse	Catostomidae	0	0	0	0	0	1	0	0	0	0	1
2	Striped jumprock	Catostomidae	0	0	0	0	1	0	0	0	0	0	1
2	White catfish	Ictaluridae	0	1	10	6	2	1	0	0	0	0	20
2	White sucker	Catostomidae	0	0	0	0	1	1	0	0	0	0	2
3	Blueback herring	Clupeidae	0	0	1	3	0	0	0	0	0	0	4
3	Bluegill	Panfishes	0	1	1	0	0	0	0	0	0	0	2
3	Channel catfish	Ictaluridae	0	0	0	1	0	0	0	0	0	0	1
3	Gizzard shad	Clupeidae	0	1	2	2	1	2	1	0	0	0	9
3	Redbreast sunfish	Panfishes	3	0	1	0	0	0	0	0	0	0	4
3	Snail bullhead	Ictaluridae	0	1	0	0	0	0	0	0	0	0	1
3	Thicklip chub	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
3	Threadfin shad	Clupeidae	0	1	0	0	0	0	0	0	0	0	1
4	Black crappie	Panfishes	0	72	1	0	1	0	0	0	0	0	74
4	Blueback herring	Clupeidae	0	0	79	21	3	0	0	0	0	0	103
4	Bluegill	Panfishes	13	98	12	3	0	0	0	0	0	0	125
4	Bluehead chub	Cyprinidae	0	0	1	0	0	0	0	0	0	0	1

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
4	Brown bullhead	Ictaluridae	0	6	3	0	0	2	0	0	0	0	11
4	Channel catfish	Ictaluridae	0	2	1	0	1	0	0	0	0	0	4
4	Flat bullhead	Ictaluridae	0	0	1	1	0	0	0	0	0	0	2
4	Flathead catfish	Ictaluridae	0	0	0	1	0	0	0	0	0	0	1
4	Gizzard shad	Clupeidae	0	0	0	0	0	6	2	0	0	0	8
4	Golden shiner	Cyprinidae	0	1	1	1	0	0	0	0	0	0	3
4	Green sunfish	Panfishes	1	2	1	0	0	0	0	0	0	0	3
4	Hybrid bass	Moronidae	0	0	0	0	0	0	2	0	0	0	2
4	Hybrid sunfish	Panfishes	8	4	0	0	0	0	0	0	0	0	12
4	Largemouth bass	Black Bass	0	1	0	0	0	0	0	0	0	0	1
4	Margined madtom	Ictaluridae	0	0	2	0	0	0	0	0	0	0	2
4	Northern hog sucker	Catostomidae	0	0	0	0	1	0	0	0	0	0	1
4	Piedmont darter	Percidae	0	1	0	0	0	0	0	0	0	0	1
4	Quillback	Catostomidae	0	0	0	0	0	1	1	0	0	0	2
4	Redbreast sunfish	Panfishes	2	6	3	1	0	0	0	0	0	0	11
4	Redear sunfish	Panfishes	0	6	0	1	0	0	0	0	0	0	7
4	Silver redhorse	Catostomidae	0	0	0	0	0	2	1	0	0	0	3
4	Smallfin redhorse	Catostomidae	0	0	0	0	0	3	0	0	0	0	3
4	Snail bullhead	Ictaluridae	0	3	2	1	1	0	1	1	0	0	8
4	Spottail shiner	Cyprinidae	0	11	7	0	0	0	0	0	0	0	18
4	Striped bass	Moronidae	0	0	3	0	0	1	1	0	0	0	5
4	Striped jumprock	Catostomidae	0	0	0	15	11	3	0	0	0	0	29
4	Threadfin shad	Clupeidae	0	1	0	0	0	0	0	0	0	0	1
4	Unid. carp	Cyprinidae	0	0	0	0	0	0	1	0	0	0	1
4	Warmouth	Panfishes	0	2	2	1	0	0	0	0	0	0	4
4	White catfish	Ictaluridae	0	0	2	0	1	1	0	0	0	0	4
4	White crappie	Panfishes	0	73	3	0	0	0	0	0	0	0	76
4	White perch	Moronidae	0	17	85	4	3	0	0	0	0	0	109
4	Whitefin shiner	Cyprinidae	1	1	1	0	0	0	0	0	0	0	3
4	Yellow perch	Percidae	0	12	88	28	0	0	0	0	0	0	128
5	Black crappie	Panfishes	0	175	35	1	1	0	0	0	0	0	212
5	Blueback herring	Clupeidae	0	0	41	21	3	0	0	0	0	0	65

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
5	Bluegill	Panfishes	7	34	15	6	0	0	0	0	0	0	63
5	Bluehead chub	Cyprinidae	1	0	0	0	0	0	0	0	0	0	1
5	Brown bullhead	Ictaluridae	0	3	0	0	0	0	0	0	0	0	3
5	Central stoneroller	Cyprinidae	0	0	1	0	0	0	0	0	0	0	1
5	Channel catfish	Ictaluridae	1	3	3	0	4	1	0	0	0	0	11
5	Common carp	Cyprinidae	0	0	0	0	0	0	1	2	0	0	3
5	Creek chub	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
5	Fieryblack shiner	Cyprinidae	1	1	0	0	0	0	0	0	0	0	2
5	Gizzard shad	Clupeidae	0	0	0	1	0	0	0	0	0	0	1
5	Golden shiner	Cyprinidae	0	0	0	1	0	0	0	0	0	0	1
5	Green sunfish	Panfishes	0	2	0	0	0	0	0	0	0	0	2
5	Margined madtom	Ictaluridae	0	0	1	0	0	0	0	0	0	0	1
5	Redbreast sunfish	Panfishes	0	1	3	1	0	0	0	0	0	0	5
5	Redear sunfish	Panfishes	0	1	2	0	0	0	0	0	0	0	3
5	Redeye bass	Black Bass	0	0	0	0	0	1	0	0	0	0	1
5	Silver redhorse	Catostomidae	0	1	0	0	0	0	0	0	0	0	1
5	Smallfin redhorse	Catostomidae	0	1	0	0	0	0	0	0	0	0	1
5	Smallmouth bass	Black Bass	0	0	0	0	1	0	1	0	0	0	2
5	Snail bullhead	Ictaluridae	0	0	7	5	0	0	0	0	0	0	12
5	Spottail shiner	Cyprinidae	0	5	1	0	0	0	0	0	0	0	6
5	Striped jumprock	Catostomidae	0	0	0	2	1	0	0	0	0	0	3
5	Threadfin shad	Clupeidae	0	56	63	0	0	0	0	0	0	0	119
5	Unid. carp	Cyprinidae	0	0	0	0	0	0	2	0	0	0	2
5	White catfish	Ictaluridae	0	0	2	1	0	0	0	0	0	0	3
5	White crappie	Panfishes	0	2	2	0	0	0	0	0	0	0	3
5	White perch	Moronidae	0	14	57	1	1	0	0	0	0	0	73
5	Whitefin shiner	Cyprinidae	0	2	0	0	0	0	0	0	0	0	2
5	Yellow perch	Percidae	0	151	380	48	0	0	0	0	0	0	580
6	Black crappie	Panfishes	0	68	44	0	1	0	0	0	0	0	113
6	Blueback herring	Clupeidae	0	0	318	486	149	0	0	0	0	0	954
6	Bluegill	Panfishes	3	29	48	45	2	1	0	0	0	0	128
6	Bluehead chub	Cyprinidae	0	2	0	0	0	0	0	0	0	0	2

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
6	Brown bullhead	Ictaluridae	0	0	0	2	1	2	0	0	0	0	5
6	Channel catfish	Ictaluridae	0	1	2	6	9	1	0	1	0	0	20
6	Common carp	Cyprinidae	2	0	0	0	1	0	0	0	0	0	3
6	Fathead minnow	Cyprinidae	1	0	0	0	0	0	0	0	0	0	1
6	Fieryblack shiner	Cyprinidae	0	3	0	0	0	0	0	0	0	0	3
6	Flat bullhead	Ictaluridae	0	0	1	0	0	0	0	0	0	0	1
6	Gizzard shad	Clupeidae	0	2	0	2	1	9	2	0	0	0	16
6	Golden shiner	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
6	Green sunfish	Panfishes	0	2	2	0	0	0	0	0	0	0	3
6	Largemouth bass	Black Bass	1	0	0	0	0	0	1	0	0	0	2
6	Margined madtom	Ictaluridae	1	0	0	0	0	0	0	0	0	0	1
6	Redbreast sunfish	Panfishes	0	3	9	14	0	0	0	0	0	0	26
6	Redear sunfish	Panfishes	0	1	1	0	1	0	0	0	0	0	3
6	Shorthead redhorse	Catostomidae	0	0	0	0	0	1	0	0	0	0	1
6	Silver redhorse	Catostomidae	0	0	0	0	0	1	0	0	0	0	1
6	Smallfin redhorse	Catostomidae	0	0	0	0	0	1	0	0	0	0	1
6	Smallmouth bass	Black Bass	0	0	0	0	1	0	0	0	0	0	1
6	Snail bullhead	Ictaluridae	0	4	37	5	4	2	0	0	0	0	52
6	Spottail shiner	Cyprinidae	0	6	2	0	0	0	0	0	0	0	8
6	Spotted bass	Black Bass	0	3	0	0	0	0	0	0	0	0	3
6	Striped jumprock	Catostomidae	0	1	0	2	1	0	0	0	0	0	4
6	Threadfin shad	Clupeidae	1	360	149	0	0	0	0	0	0	0	510
6	Unid. carp	Cyprinidae	0	0	0	0	0	2	2	0	0	0	4
6	White catfish	Ictaluridae	0	5	3	4	3	5	0	0	0	0	20
6	White crappie	Panfishes	1	5	1	0	0	0	0	0	0	0	7
6	White perch	Moronidae	0	0	10	2	0	0	0	0	0	0	11
6	Whitefin shiner	Cyprinidae	0	3	0	0	0	0	0	0	0	0	3
6	Yellow perch	Percidae	0	162	276	20	0	0	0	0	0	0	457
7	Black crappie	Panfishes	0	35	19	0	0	0	0	0	0	0	54
7	Blueback herring	Clupeidae	0	3	89	176	22	0	0	0	0	0	290
7	Bluegill	Panfishes	6	78	14	0	0	0	0	0	0	0	98
7	Brown bullhead	Ictaluridae	0	10	8	6	2	9	0	0	0	0	36

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
7	Channel catfish	Ictaluridae	0	1	0	0	0	0	0	0	0	0	1
7	Gizzard shad	Clupeidae	0	0	0	0	0	14	0	0	0	0	14
7	Green sunfish	Panfishes	0	2	0	0	0	0	0	0	0	0	2
7	Rainbow trout	Salmonidae	0	0	0	0	0	1	1	0	0	0	2
7	Threadfin shad	Clupeidae	13	1628	217	0	0	0	0	0	0	0	1859
7	Unid. carp	Cyprinidae	0	0	0	0	0	0	22	1	0	0	23
7	Warmouth	Panfishes	0	2	2	0	0	0	0	0	0	0	5
7	White catfish	Ictaluridae	0	10	6	3	0	0	0	0	0	0	19
7	White crappie	Panfishes	0	0	2	0	0	0	0	0	0	0	2
7	White perch	Moronidae	0	0	3	0	0	0	0	0	0	0	3
7	Whitefin shiner	Cyprinidae	0	1	1	0	0	0	0	0	0	0	2
7	Yellow bullhead	Ictaluridae	0	0	0	0	0	7	0	0	0	0	7
7	Yellow perch	Percidae	0	144	295	17	0	0	0	0	0	0	455
8	Blueback herring	Clupeidae	0	1242	70	212	45	0	0	0	0	0	1570
8	Bluegill	Panfishes	18	134	9	3	1	0	0	0	0	0	165
8	Brown bullhead	Ictaluridae	0	0	0	0	0	6	0	0	0	0	6
8	Channel catfish	Ictaluridae	0	1	0	0	0	1	0	0	0	0	2
8	Gizzard shad	Clupeidae	0	0	0	0	0	4	0	0	0	0	4
8	Snail bullhead	Ictaluridae	0	0	1	0	0	0	0	0	0	0	1
8	Spottail shiner	Cyprinidae	0	13	0	0	0	0	0	0	0	0	13
8	Threadfin shad	Clupeidae	0	3227	517	0	0	0	0	0	0	0	3744
8	Unid. carp	Cyprinidae	0	0	0	0	0	0	0	0	2	0	2
8	Warmouth	Panfishes	0	2	2	0	0	0	0	0	0	0	3
8	White catfish	Ictaluridae	0	4	19	8	4	1	0	0	0	0	36
8	Yellow perch	Percidae	0	25	127	7	0	2	0	0	0	0	161
9	Black crappie	Panfishes	0	1	0	0	1	0	0	0	0	0	2
9	Bluegill	Panfishes	6	6	32	12	0	0	0	0	0	0	56
9	Channel catfish	Ictaluridae	0	17	5	15	5	1	0	0	0	0	43
9	Common carp	Cyprinidae	0	0	1	0	0	0	0	0	0	0	1
9	Fieryblack shiner	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
9	Flat bullhead	Ictaluridae	0	0	0	0	0	2	0	0	0	0	2
9	Gizzard shad	Clupeidae	0	0	1	0	1	0	0	0	0	0	2

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
9	Golden shiner	Cyprinidae	1	5	0	0	0	0	0	0	0	0	6
9	Largemouth bass	Black Bass	0	0	0	0	0	0	3	0	0	0	3
9	Piedmont darter	Percidae	0	1	0	0	0	0	0	0	0	0	1
9	Redbreast sunfish	Panfishes	0	1	5	0	0	0	0	0	0	0	6
9	Redear sunfish	Panfishes	0	0	0	0	1	0	0	0	0	0	1
9	Sandbar shiner	Cyprinidae	0	15	0	0	0	0	0	0	0	0	15
9	Shorthead redhorse	Catostomidae	0	0	0	0	1	1	0	0	0	0	2
9	Snail bullhead	Ictaluridae	0	4	0	3	3	0	0	0	0	0	10
9	Striped jumprock	Catostomidae	0	0	0	0	2	0	0	0	0	0	2
9	Threadfin shad	Clupeidae	0	8	9	0	0	0	0	0	0	0	17
9	White catfish	Ictaluridae	0	5	0	2	0	1	0	0	0	0	8
9	White crappie	Panfishes	0	0	0	1	0	0	0	0	0	0	1
9	Whitefin shiner	Cyprinidae	3	0	0	0	0	0	0	0	0	0	3
10	Black crappie	Panfishes	0	0	1	1	1	0	0	0	0	0	3
10	Blueback herring	Clupeidae	0	0	47	408	68	0	0	0	0	0	523
10	Bluegill	Panfishes	8	27	28	41	2	0	0	0	0	0	106
10	Brown bullhead	Ictaluridae	0	0	3	7	1	0	0	0	0	0	11
10	Channel catfish	Ictaluridae	0	1	2	2	1	0	0	0	0	0	6
10	Fieryblack shiner	Cyprinidae	0	3	0	0	0	0	0	0	0	0	3
10	Flat bullhead	Ictaluridae	0	1	0	1	0	0	0	0	0	0	2
10	Flathead catfish	Ictaluridae	0	0	1	1	0	0	0	0	0	0	1
10	Gizzard shad	Clupeidae	0	0	2	0	0	3	0	0	0	0	5
10	Golden shiner	Cyprinidae	0	0	0	1	0	0	0	0	0	0	1
10	Largemouth bass	Black Bass	0	0	0	0	0	0	1	0	0	0	1
10	Redbreast sunfish	Panfishes	0	0	3	2	0	0	0	0	0	0	5
10	Redear sunfish	Panfishes	0	0	0	3	4	0	0	0	0	0	7
10	Redeye bass	Black Bass	0	0	0	1	0	0	0	0	0	0	1
10	Smallfin redhorse	Catostomidae	0	0	0	0	0	1	0	0	0	0	1
10	Snail bullhead	Ictaluridae	0	1	1	0	0	0	0	0	0	0	2
10	Spottail shiner	Cyprinidae	0	0	1	0	0	0	0	0	0	0	1
10	Striped jumprock	Catostomidae	0	1	0	4	2	0	0	0	0	0	7
10	Threadfin shad	Clupeidae	99	374	37	0	0	0	0	0	0	0	511

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
10	Unid. carp	Cyprinidae	0	0	0	0	0	0	16	0	0	0	16
10	White bass	Moronidae	0	0	0	0	0	2	0	0	0	0	2
10	White catfish	Ictaluridae	1	72	155	150	40	0	0	0	0	0	418
10	White perch	Moronidae	0	0	0	1	1	0	0	0	0	0	2
10	Whitefin shiner	Cyprinidae	0	6	1	0	0	0	0	0	0	0	7
10	Yellow perch	Percidae	0	13	34	3	0	0	0	0	0	0	50
11	Black crappie	Panfishes	0	1	3	0	6	1	0	0	0	0	11
11	Blueback herring	Clupeidae	0	59	58	288	47	0	0	0	0	0	451
11	Bluegill	Panfishes	10	116	13	7	0	0	0	0	0	0	147
11	Brown bullhead	Ictaluridae	0	29	102	35	10	2	1	0	0	0	179
11	Channel catfish	Ictaluridae	1	6	43	16	4	2	1	0	0	0	74
11	Flat bullhead	Ictaluridae	0	0	0	1	1	0	0	0	0	0	2
11	Flathead catfish	Ictaluridae	0	0	2	3	1	1	0	0	0	0	7
11	Gizzard shad	Clupeidae	0	3	19	3	14	12	1	0	0	0	52
11	Hybrid bass	Moronidae	0	0	0	0	0	0	1	0	0	0	1
11	Largemouth bass	Black Bass	0	0	0	0	0	0	1	0	0	0	1
11	Northern hog sucker	Catostomidae	0	0	0	0	1	0	0	0	0	0	1
11	Redbreast sunfish	Panfishes	0	0	2	4	0	0	0	0	0	0	6
11	Silver redhorse	Catostomidae	0	0	0	1	0	0	0	0	0	0	1
11	Snail bullhead	Ictaluridae	0	0	0	1	0	0	0	0	0	0	1
11	Spotted bass	Black Bass	0	0	0	0	0	1	0	0	0	0	1
11	Striped jumprock	Catostomidae	0	0	0	1	5	2	0	0	0	0	8
11	Threadfin shad	Clupeidae	3192	9962	821	0	0	0	0	0	0	0	13976
11	Unid. carp	Cyprinidae	0	0	0	0	0	0	1	0	3	0	4
11	Warmouth	Panfishes	0	3	0	0	0	0	0	0	0	0	3
11	White catfish	Ictaluridae	3	56	154	114	34	3	0	0	0	0	364
11	White crappie	Panfishes	0	1	0	0	0	0	0	0	0	0	1
11	White perch	Moronidae	0	0	0	3	3	2	0	0	0	0	7
11	White sucker	Catostomidae	0	0	0	0	1	0	0	0	0	0	1
11	Yellow bullhead	Ictaluridae	0	0	0	0	0	2	0	0	0	0	2
11	Yellow perch	Percidae	0	21	100	24	1	0	0	0	0	0	147
12	Black crappie	Panfishes	0	2	0	0	0	1	0	0	0	0	3

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
12	Bluegill	Panfishes	0	1	3	1	0	0	0	0	0	0	5
12	Channel catfish	Ictaluridae	0	0	0	0	0	1	0	0	0	0	1
12	Gizzard shad	Clupeidae	0	0	45	3	0	0	0	0	0	0	48
12	Piedmont darter	Percidae	0	2	0	0	0	0	0	0	0	0	2
12	Smallfin redhorse	Catostomidae	0	0	0	1	0	2	0	0	0	0	3
12	Snail bullhead	Ictaluridae	0	1	0	1	0	0	0	0	0	0	2
12	Tessellated darter	Percidae	0	1	0	0	0	0	0	0	0	0	1
12	White bass	Moronidae	0	0	0	0	0	2	0	0	0	0	2
12	White catfish	Ictaluridae	0	0	1	0	0	0	0	0	0	0	1
12	Yellow perch	Percidae	0	0	0	3	1	0	0	0	0	0	4
Total ¹	53	8	3,420	18,840	4,966	2,403	580	148	67	5	5	0	30,433

¹ The database contains 53 species from 8 families and a total of 30,433 fish spread across the range of length classes. These totals do not account for the use of surrogates for missing months or family data.

APPENDIX B

FAMILY MONTHLY AND SEASONAL LENGTH CLASS PERCENTAGE

FAMILY MONTHLY AND SEASONAL LENGTH CLASS PERCENTAGE

CATOSTOMIDAE

MONT	0-2"	2.1-	4.1-	6.1-	8.1-	10.1-	15.1-	20.1-	25.1-	>30	TOTA	
1	0.0	0.0%	0.0%	14.3	42.9%	42.9%	0.0%	0.0%	0.0%	0.0	100.0	*sub February data for Jan
2	0.0	0.0%	0.0%	14.3	42.9%	42.9%	0.0%	0.0%	0.0%	0.0	100.0	
3	0.0	0.0%	0.0%	39.5	31.6%	23.7%	5.3%	0.0%	0.0%	0.0	100.0	*sub April data for March
4	0.0	0.0%	0.0%	39.5	31.6%	23.7%	5.3%	0.0%	0.0%	0.0	100.0	
5	0.0	40.0	0.0%	40.0	20.0%	0.0%	0.0%	0.0%	0.0%	0.0	100.0	
6	0.0	14.3	0.0%	28.6	14.3%	42.9%	0.0%	0.0%	0.0%	0.0	100.0	
7	0.0	14.3	0.0%	28.6	14.3%	42.9%	0.0%	0.0%	0.0%	0.0	100.0	*sub June data for July
8	0.0	14.3	0.0%	28.6	14.3%	42.9%	0.0%	0.0%	0.0%	0.0	100.0	*sub June data for August
9	0.0	0.0%	0.0%	0.0%	75.0%	25.0%	0.0%	0.0%	0.0%	0.0	100.0	
10	0.0	12.5	0.0%	50.0	25.0%	12.5%	0.0%	0.0%	0.0%	0.0	100.0	
11	0.0	0.0%	0.0%	18.2	63.6%	18.2%	0.0%	0.0%	0.0%	0.0	100.0	
12	0.0	0.0%	0.0%	33.3	0.0%	66.7%	0.0%	0.0%	0.0%	0.0	100.0	

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	0.0%	0.0%	17.6%	35.3%	47.1%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	0.0%	2.5%	0.0%	39.5%	30.9%	22.2%	4.9%	0.0%	0.0%	0.0%	100%
SUMMER	0.0%	14.3%	0.0%	28.6%	14.3%	42.9%	0.0%	0.0%	0.0%	0.0%	100%
FALL	0.0%	4.3%	0.0%	26.1%	52.2%	17.4%	0.0%	0.0%	0.0%	0.0%	100%
TOTAL	0.0%	4.2%	0.0%	33.1%	32.4%	27.5%	2.8%	0.0%	0.0%	0.0%	100%

BLACK BASS

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL	
1	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for January
2	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
3	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub April data for March
4	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
5	0.0%	0.0%	0.0%	0.0%	33.3%	33.3%	33.3%	0.0%	0.0%	0.0%	100.0%	
6	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	
7	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	*sub June data for July
8	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	*sub June data for August
9	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	
10	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	100.0%	
11	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	0.0%	0.0%	0.0%	100.0%	
12	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for December

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	0.0%	25.0%	0.0%	0.0%	25.0%	25.0%	25.0%	0.0%	0.0%	0.0%	100%
SUMMER	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100%
FALL	0.0%	0.0%	0.0%	14.3%	0.0%	14.3%	71.4%	0.0%	0.0%	0.0%	100%
TOTAL	5.7%	26.2%	0.0%	5.7%	11.4%	11.4%	39.8%	0.0%	0.0%	0.0%	100%

PANFISH

MONT	0-2"	2.1-	4.1-	6.1-	8.1-	10.1-	15.1-	20.1-	25.1-	>30	TOTAL
1	71.4	14.3%	7.1%	7.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
2	71.4	14.3%	7.1%	7.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
3	50.0	16.7%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
4	7.5%	83.5%	6.7%	2.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
5	2.5%	74.6%	19.8%	2.8%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
6	1.5%	38.5%	37.2%	21.1%	1.4%	0.4%	0.0%	0.0%	0.0%	0.0%	100.0
7	3.6%	73.5%	23.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
8	10.8	80.5%	6.3%	1.8%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
9	9.1%	12.1%	56.1%	19.7%	3.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
10	6.2%	22.7%	26.3%	38.9%	5.8%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
11	6.2%	72.1%	10.7%	6.7%	3.7%	0.6%	0.0%	0.0%	0.0%	0.0%	100.0
12	0.0%	37.5%	37.5%	12.5%	0.0%	12.5%	0.0%	0.0%	0.0%	0.0%	100.0

*sub February data for

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	45.5%	22.7%	18.2%	9.1%	0.0%	4.5%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	5.6%	78.6%	13.2%	2.3%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SUMMER	4.6%	59.3%	24.9%	10.2%	0.8%	0.2%	0.0%	0.0%	0.0%	0.0%	100%
FALL	6.7%	44.1%	24.5%	20.1%	4.3%	0.3%	0.0%	0.0%	0.0%	0.0%	100%
TOTAL	6.0%	62.8%	20.2%	9.4%	1.4%	0.2%	0.0%	0.0%	0.0%	0.0%	100%

CLUPEIDAE

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
1	0.0%	25.0%	8.3%	41.7%	8.3%	16.7%	0.0%	0.0%	0.0%	0.0%	100.0%
2	0.0%	25.0%	8.3%	41.7%	8.3%	16.7%	0.0%	0.0%	0.0%	0.0%	100.0%
3	0.0%	14.3%	21.4%	35.7%	7.1%	14.3%	7.1%	0.0%	0.0%	0.0%	100.0%
4	0.0%	0.9%	70.4%	18.8%	2.8%	5.4%	1.8%	0.0%	0.0%	0.0%	100.0%
5	0.0%	30.1%	56.3%	11.9%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
6	0.1%	24.4%	31.6%	33.0%	10.1%	0.6%	0.1%	0.0%	0.0%	0.0%	100.0%
7	0.6%	75.4%	14.2%	8.2%	1.0%	0.6%	0.0%	0.0%	0.0%	0.0%	100.0%
8	0.0%	84.0%	11.0%	4.0%	0.8%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%
9	0.0%	42.1%	52.6%	0.0%	5.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
10	9.6%	36.0%	8.3%	39.2%	6.6%	0.3%	0.0%	0.0%	0.0%	0.0%	100.0%
11	22.0%	69.2%	6.2%	2.0%	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%
12	0.0%	0.0%	93.8%	6.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%

*sub February data for January

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	5.0%	76.7%	13.3%	1.7%	3.3%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	0.0%	18.9%	59.8%	15.4%	2.3%	2.6%	1.0%	0.0%	0.0%	0.0%	100%
SUMMER	0.2%	72.1%	15.2%	9.8%	2.4%	0.3%	0.0%	0.0%	0.0%	0.0%	100%
FALL	21.2%	67.0%	6.4%	4.5%	0.8%	0.1%	0.0%	0.0%	0.0%	0.0%	100%
TOTAL	13.3%	68.1%	10.4%	6.6%	1.4%	0.2%	0.0%	0.0%	0.0%	0.0%	100%

CYPRINIDAE

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL	
1	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for January
2	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
3	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
4	3.8%	49.2%	39.4%	3.8%	0.0%	0.0%	3.8%	0.0%	0.0%	0.0%	100.0%	
5	10.5%	47.4%	10.7%	5.2%	0.0%	0.0%	15.7%	10.5%	0.0%	0.0%	100.0%	
6	11.9%	59.9%	8.3%	0.0%	4.0%	7.9%	7.9%	0.0%	0.0%	0.0%	100.0%	
7	0.0%	4.2%	4.2%	0.0%	0.0%	0.0%	87.6%	4.0%	0.0%	0.0%	100.0%	
8	0.0%	86.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.3%	0.0%	100.0%	
9	15.4%	80.8%	3.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
10	0.0%	32.1%	7.1%	3.6%	0.0%	0.0%	57.1%	0.0%	0.0%	0.0%	100.0%	
11	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	0.0%	75.0%	0.0%	100.0%	*sub February data for December
12	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	6.5%	49.5%	26.8%	4.3%	0.0%	0.0%	8.6%	4.3%	0.0%	0.0%	100%
SUMMER	4.6%	44.6%	4.8%	0.0%	1.5%	3.1%	36.8%	1.5%	3.1%	0.0%	100%
FALL	6.9%	51.7%	5.2%	1.7%	0.0%	0.0%	29.3%	0.0%	5.2%	0.0%	100%
TOTAL	5.7%	49.3%	10.6%	2.3%	0.6%	1.1%	25.7%	1.7%	2.9%	0.0%	100%

ICTALURIDAE

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
1	0.0%	2.5%	14.8%	40.7%	35.8%	6.2%	0.0%	0.0%	0.0%	0.0%	100.0%
2	0.0%	2.5%	14.8%	40.7%	35.8%	6.2%	0.0%	0.0%	0.0%	0.0%	100.0%
3	0.0%	50.0%	0.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
4	0.0%	34.5%	33.3%	10.5%	9.3%	9.3%	1.6%	1.6%	0.0%	0.0%	100.0%
5	2.3%	21.1%	42.8%	19.5%	12.0%	2.3%	0.0%	0.0%	0.0%	0.0%	100.0%
6	1.0%	10.3%	43.2%	17.0%	17.4%	10.0%	0.0%	1.0%	0.0%	0.0%	100.0%
7	0.0%	34.9%	21.8%	15.3%	3.3%	24.7%	0.0%	0.0%	0.0%	0.0%	100.0%
8	0.0%	11.6%	44.2%	17.1%	9.3%	17.9%	0.0%	0.0%	0.0%	0.0%	100.0%
9	0.0%	41.3%	7.9%	31.7%	12.7%	6.3%	0.0%	0.0%	0.0%	0.0%	100.0%
10	0.3%	17.0%	36.7%	36.3%	9.7%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
11	0.7%	14.5%	47.8%	27.1%	8.1%	1.6%	0.2%	0.0%	0.0%	0.0%	100.0%
12	0.0%	25.0%	25.0%	25.0%	0.0%	25.0%	0.0%	0.0%	0.0%	0.0%	100.0%

*sub February data for January

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	3.5%	15.3%	40.0%	34.1%	7.1%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	1.1%	28.6%	36.8%	16.0%	10.3%	5.7%	0.8%	0.8%	0.0%	0.0%	100%
SUMMER	0.5%	18.1%	36.9%	16.5%	11.4%	16.2%	0.0%	0.5%	0.0%	0.0%	100%
FALL	0.5%	17.0%	41.3%	30.9%	9.0%	1.3%	0.1%	0.0%	0.0%	0.0%	100%
TOTAL	0.5%	16.9%	39.0%	28.8%	10.8%	3.9%	0.1%	0.1%	0.0%	0.0%	100%

LEPISOSTEIDAE²

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL	
1	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for January
2	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
3	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub April data for March
4	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
5	0.0%	0.0%	0.0%	0.0%	33.3%	33.3%	33.3%	0.0%	0.0%	0.0%	100.0%	
6	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	
7	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	*sub June data for July
8	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	*sub June data for August
9	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	
10	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	100.0%	
11	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	0.0%	0.0%	0.0%	100.0%	
12	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for December

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	0.0%	25.0%	0.0%	0.0%	25.0%	25.0%	25.0%	0.0%	0.0%	0.0%	100%
SUMMER	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100%
FALL	0.0%	0.0%	0.0%	14.3%	0.0%	14.3%	71.4%	0.0%	0.0%	0.0%	100%
TOTAL	5.7%	26.2%	0.0%	5.7%	11.4%	11.4%	39.8%	0.0%	0.0%	0.0%	100%

² No length class data. Black bass used as surrogate.

MORONIDAE

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL	
1	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub December data for January
2	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub December data for February
3	0.0%	14.7%	75.8%	3.5%	2.5%	0.9%	2.6%	0.0%	0.0%	0.0%	100.0%	*sub April for March
4	0.0%	14.7%	75.8%	3.5%	2.5%	0.9%	2.6%	0.0%	0.0%	0.0%	100.0%	
5	0.0%	19.7%	77.9%	1.6%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
6	0.0%	0.0%	84.7%	15.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
7	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
8	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub July for August
9	0.0%	0.0%	0.0%	25.0%	25.0%	50.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub October data for September
10	0.0%	0.0%	0.0%	25.0%	25.0%	50.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
11	0.0%	0.0%	0.0%	32.9%	31.0%	24.1%	12.0%	0.0%	0.0%	0.0%	100.0%	
12	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%	

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	0.0%	16.7%	76.6%	2.8%	1.8%	0.5%	1.6%	0.0%	0.0%	0.0%	100%
SUMMER	0.0%	0.0%	87.6%	12.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
FALL	0.0%	0.0%	0.0%	30.3%	29.1%	32.5%	8.1%	0.0%	0.0%	0.0%	100%
TOTAL	0.0%	14.5%	72.3%	4.9%	3.3%	3.2%	1.8%	0.0%	0.0%	0.0%	100%

PERCIDAE

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
1	0.0%	42.9%	0.0%	42.9%	14.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
2	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
3	0.0%	9.9%	68.6%	21.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
4	0.0%	9.9%	68.6%	21.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
5	0.0%	26.1%	65.6%	8.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
6	0.0%	35.4%	60.3%	4.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
7	0.0%	31.5%	64.8%	3.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
8	0.0%	15.4%	79.0%	4.3%	0.0%	1.2%	0.0%	0.0%	0.0%	0.0%	100.0%
9	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
10	0.0%	26.0%	68.2%	5.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
11	0.0%	14.2%	68.3%	16.7%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
12	0.0%	42.9%	0.0%	42.9%	14.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%

*sub December for January

*sub April for March

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	46.7%	0.0%	40.0%	13.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	0.0%	21.1%	66.5%	12.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SUMMER	0.0%	30.8%	65.0%	4.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	100%
FALL	0.0%	17.7%	67.9%	13.8%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
TOTAL	0.0%	25.9%	65.4%	8.5%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	100%

FUNDULIDAE³

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
1	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
2	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
3	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
4	3.8%	49.2%	39.4%	3.8%	0.0%	0.0%	3.8%	0.0%	0.0%	0.0%	100.0%
5	10.5%	47.4%	10.7%	5.2%	0.0%	0.0%	15.7%	10.5%	0.0%	0.0%	100.0%
6	11.9%	59.9%	8.3%	0.0%	4.0%	7.9%	7.9%	0.0%	0.0%	0.0%	100.0%
7	0.0%	4.2%	4.2%	0.0%	0.0%	0.0%	87.6%	4.0%	0.0%	0.0%	100.0%
8	0.0%	86.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.3%	0.0%	100.0%
9	15.4%	80.8%	3.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
10	0.0%	32.1%	7.1%	3.6%	0.0%	0.0%	57.1%	0.0%	0.0%	0.0%	100.0%
11	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	0.0%	75.0%	0.0%	100.0%
12	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%

*sub February data for January

*sub February data for December

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	6.5%	49.5%	26.8%	4.3%	0.0%	0.0%	8.6%	4.3%	0.0%	0.0%	100%
SUMMER	4.6%	44.6%	4.8%	0.0%	1.5%	3.1%	36.8%	1.5%	3.1%	0.0%	100%
FALL	6.9%	51.7%	5.2%	1.7%	0.0%	0.0%	29.3%	0.0%	5.2%	0.0%	100%
TOTAL	5.7%	49.3%	10.6%	2.3%	0.6%	1.1%	25.7%	1.7%	2.9%	0.0%	100%

³ No length class data. Cyprinidae used as surrogate.

ESOCIDAE⁴

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL	
1	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for January
2	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
3	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub April data for March
4	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
5	0.0%	0.0%	0.0%	0.0%	33.3%	33.3%	33.3%	0.0%	0.0%	0.0%	100.0%	
6	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	
7	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	*sub June data for July
8	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	*sub June data for August
9	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	
10	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	100.0%	
11	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	0.0%	0.0%	0.0%	100.0%	*sub October data for November
12	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for December

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	0.0%	25.0%	0.0%	0.0%	25.0%	25.0%	25.0%	0.0%	0.0%	0.0%	100%
SUMMER	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100%
FALL	0.0%	0.0%	0.0%	14.3%	0.0%	14.3%	71.4%	0.0%	0.0%	0.0%	100%
TOTAL	5.7%	26.2%	0.0%	5.7%	11.4%	11.4%	39.8%	0.0%	0.0%	0.0%	100%

⁴ No length class data. Black bass used as surrogate.

APPENDIX C

2015 FAIRFIELD ENTRAINMENT ESTIMATES

2015 FAIRFIELD ENTRAINMENT ESTIMATES

TOTAL FISH ENTRAINMENT ESTIMATE

		SEASONAL ENTRAINMENT RATE (fish/mcf) CONVENTIONAL GEN	SEASONAL ENTRAINMENT RATE (fish/mcf) PUMPBACK GEN	TOTAL MONTHLY PROJECT FLOWS (mcf)	TOTAL ESTIMATED NUMBER OF FISH ENTRAINED BY MONTH CONVENTIONAL GEN	TOTAL ESTIMATED NUMBER OF FISH ENTRAINED BY MONTH PUMPBACK GEN	TOTAL ESTIMATED NUMBER FISH ENTRAINED BY SEASON CONVENTIONAL GENERATION	TOTAL ESTIMATED NUMBER FISH ENTRAINED BY SEASON PUMPBACK GENERATION
Winter	December	9.2	3.2	14,203	130667.6	45,449.6	374,026	130,096
	January	9.2	3.2	11,969	110114.8	38,300.8		
	February	9.2	3.2	14,483	133243.6	46,345.6		
Spring	March	2.5	6.3	18,237	45592.5	114,893.1	169,495	427,127
	April	2.5	6.3	23,287	58217.5	146,708.1		
	May	2.5	6.3	26,274	65685	165,526.2		
Summer	June	1.7	16.4	28,142	47841.4	461,528.8	137,846	1,329,810
	July	1.7	16.4	29,049	49383.3	476,403.6		
	August	1.7	16.4	23,895	40621.5	391,878		
Fall	September	2.6	11.5	19,622	51017.2	225,653	132,891	587,788
	October	2.6	11.5	16,077	41800.2	184,885.5		
	November	2.6	11.5	15,413	40073.8	177,249.5		
Annual							814,258	2,474,822

CONVENTIONAL GENERATION FISH ENTRAINMENT ESTIMATE

	WINTER	SPRING	SUMMER	FALL	ANNUAL
Catostomidae	25	44	33	0	103
Black Bass	3	21	69	56	148
Panfish	633	7,830	14,520	1,861	24,843
Clupeidae	350,027	72,192	96,559	102,794	621,573
Cyprinidae	407	815	679	794	2,695
Ictaluridae	12,872	1,224	3,507	24,617	42,220
Lepisosteidae	3	0	31	0	33
Moronidae	15	8,532	465	43	9,056
Percidae	10,028	78,737	21,950	2,725	113,441
TOTAL	374,014	169,393	137,846	132,891	814,144

PUMPBACK FISH ENTRAINMENT ESTIMATE

	WINTER	SPRING	SUMMER	FALL	ANNUAL
Catostomidae	8	9	3	37	57
Black Bass	62	0	8,385	279	8,727
Panfish	371	41,921	6,032	1,677	50,001
Clupeidae	128,476	316,097	1,281,433	580,469	2,306,475
Cyprinidae	15	4,557	3,234	66	7,872
Ictaluridae	867	7,874	3,916	3,918	16,576
Lepisosteidae	1	0	22	3	26
Moronidae	250	50,188	23,711	1,130	75,279
Percidae	46	6,464	2,851	209	9,570
Fundulidae	0	18	154	0	171
Esocidae	0	0	69	0	69
TOTAL	130,096	427,127	1,329,810	587,788	2,474,822

APPENDIX D

FAMILY LENGTH CLASS ENTRAINMENT AND MORTALITY ESTIMATES

FAMILY LENGTH CLASS ENTRAINMENT AND MORTALITY ESTIMATES

Catostomidae					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	4	0	8.0	1	0
10.0	9	1	10.0	3	0
15.0	12	2	15.0	4	1
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	25	3	Total	8	1
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	1	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	18	1	8.0	4	0
10.0	14	1	10.0	3	0
15.0	10	1	15.0	2	0
20.0	2	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	44	4	Total	9	1
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	5	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	10	1	8.0	1	0
10.0	5	0	10.0	0	0
15.0	14	2	15.0	1	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	33	3	Total	3	0
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	2	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	10	1
10.0	0	0	10.0	19	2
15.0	0	0	15.0	6	1
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	0	0	Total	37	3
Annual Total	103	10	Annual Total	57	5

Black Bass					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	3	0	4.0	62	2
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	3	0	Total	62	2
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	8	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	4	0	10.0	0	0
15.0	4	1	15.0	0	0
20.0	4	1	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	21	2	Total	0	0
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	12	0	2.0	1495	28
4.0	32	1	4.0	3901	144
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	12	1	10.0	1495	138
15.0	0	0	15.0	0	0
20.0	12	2	20.0	1495	276
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	69	4	Total	8385	585
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	8	1	8.0	40	3
10.0	0	0	10.0	0	0
15.0	8	1	15.0	40	6
20.0	40	7	20.0	200	37
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	56	9	Total	279	45
Annual Total	148	15	Annual Total	8727	633

Panfish					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	352	6	2.0	206	4
4.0	123	4	4.0	72	3
6.0	88	5	6.0	52	3
8.0	53	4	8.0	31	2
10.0	0	0	10.0	0	0
15.0	18	2	15.0	10	1
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	633	21	Total	371	13
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	435	7	2.0	2327	43
4.0	6156	212	4.0	32960	1217
6.0	1031	53	6.0	5519	306
8.0	182	13	8.0	977	72
10.0	26	2	10.0	138	13
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	7830	288	Total	41921	1650
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	669	12	2.0	278	5
4.0	8612	297	4.0	3578	132
6.0	3615	187	6.0	1502	83
8.0	1481	102	8.0	615	45
10.0	119	10	10.0	50	5
15.0	24	3	15.0	10	1
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	14520	611	Total	6032	272
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	125	2	2.0	113	2
4.0	821	28	4.0	740	27
6.0	455	24	6.0	410	23
8.0	374	26	8.0	337	25
10.0	80	7	10.0	72	7
15.0	5	1	15.0	5	1
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	1861	87	Total	1677	84
Annual Total	24843	1006	Annual Total	50001	2019

Clupeidae					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	29169	1005	4.0	10706	395
6.0	228490	11811	6.0	83866	4644
8.0	63199	4356	8.0	23197	1713
10.0	9723	838	10.0	3569	329
15.0	19446	2513	15.0	7138	988
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	350027	20523	Total	128476	8069
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	13611	469	4.0	59595	2200
6.0	43188	2232	6.0	189101	10470
8.0	11146	768	8.0	48802	3603
10.0	1694	146	10.0	7419	685
15.0	1857	240	15.0	8130	1125
20.0	696	120	20.0	3049	563
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	72192	3976	Total	316097	18646
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	153	3	2.0	2032	38
4.0	69632	2400	4.0	924082	34111
6.0	14668	758	6.0	194661	10778
8.0	9451	651	8.0	125420	9259
10.0	2343	202	10.0	31090	2869
15.0	291	38	15.0	3861	534
20.0	22	4	20.0	286	53
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	96559	4055	Total	1281433	57642
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	21780	375	2.0	122987	2270
4.0	68846	2373	4.0	388769	14351
6.0	6578	340	6.0	37145	2057
8.0	4621	318	8.0	26093	1926
10.0	864	74	10.0	4877	450
15.0	99	13	15.0	560	78
20.0	7	1	20.0	37	7
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	102794	3495	Total	580469	21138
Annual Total	621573	32048	Annual Total	2306475	105495

Cyprinidae					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	326	11	4.0	12	0
6.0	0	0	6.0	0	0
8.0	81	6	8.0	3	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	407	17	Total	15	1
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	53	1	2.0	294	5
4.0	404	14	4.0	2258	78
6.0	218	11	6.0	1221	63
8.0	35	2	8.0	196	14
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	70	12	20.0	392	68
25.0	35	8	25.0	196	42
30.0	0	0	30.0	0	0
Total	815	48	Total	4557	269
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	31	1	2.0	149	3
4.0	303	10	4.0	1444	50
6.0	33	2	6.0	156	8
8.0	0	0	8.0	0	0
10.0	10	1	10.0	50	4
15.0	21	3	15.0	99	13
20.0	249	43	20.0	1189	205
25.0	10	2	25.0	50	11
30.0	21	5	30.0	99	26
Total	679	67	Total	3234	319
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	55	1	2.0	5	0
4.0	411	14	4.0	34	1
6.0	41	2	6.0	3	0
8.0	14	1	8.0	1	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	233	40	20.0	19	3
25.0	0	0	25.0	0	0
30.0	41	11	30.0	3	1
Total	794	69	Total	66	6
Annual Total	2695	201	Annual Total	7872	594

Ictaluridae					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	388	13	4.0	26	1
6.0	1939	100	6.0	131	7
8.0	5195	358	8.0	350	24
10.0	4497	387	10.0	303	26
15.0	853	110	15.0	57	7
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	12872	969	Total	867	65
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	13	0	2.0	85	1
4.0	350	12	4.0	2252	78
6.0	450	23	6.0	2895	150
8.0	196	13	8.0	1260	87
10.0	126	11	10.0	813	70
15.0	70	9	15.0	449	58
20.0	9	2	20.0	61	10
25.0	9	2	25.0	61	13
30.0	0	0	30.0	0	0
Total	1224	73	Total	7874	467
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	17	0	2.0	19	0
4.0	635	22	4.0	709	24
6.0	1293	67	6.0	1444	75
8.0	579	40	8.0	647	45
10.0	398	34	10.0	445	38
15.0	568	73	15.0	634	82
20.0	0	0	20.0	0	0
25.0	17	4	25.0	19	4
30.0	0	0	30.0	0	0
Total	3507	240	Total	3916	268
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	121	2	2.0	19	0
4.0	4174	144	4.0	664	23
6.0	10158	525	6.0	1617	84
8.0	7618	525	8.0	1212	84
10.0	2204	190	10.0	351	30
15.0	309	40	15.0	49	6
20.0	33	6	20.0	5	1
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	24617	1432	Total	3918	228
Annual Total	42220	2714	Annual Total	16576	1028

Lepisosteidae⁵					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	3	0	4.0	1	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	3	0	Total	1	0
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	0	0	Total	0	0
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	5	0	2.0	4	0
4.0	14	0	4.0	10	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	5	0	10.0	4	0
15.0	0	0	15.0	0	0
20.0	5	1	20.0	4	1
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	31	2	Total	22	1
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	2	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	0	0	Total	3	0
Annual Total	33	2	Annual Total	26	2

⁵ Black Bass used as a surrogate for length class distribution. Likely underestimates fish length.

Moronidae					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	0	0
15.0	15	2	15.0	250	32
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	15	2	Total	250	32
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	1358	47	4.0	7987	275
6.0	6511	337	6.0	38303	1980
8.0	259	18	8.0	1526	105
10.0	178	15	10.0	1048	90
15.0	56	7	15.0	331	43
20.0	169	29	20.0	992	171
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	8532	453	Total	50188	2664
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	417	22	6.0	21226	1097
8.0	49	3	8.0	2485	171
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	465	25	Total	23711	1268
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	13	1	8.0	328	23
10.0	12	1	10.0	317	27
15.0	16	2	15.0	416	54
20.0	3	0	20.0	69	12
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	43	4	Total	1130	116
Annual Total	9056	484	Annual Total	75279	4081

Percidae					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	4680	161	4.0	22	1
6.0	0	0	6.0	0	0
8.0	4011	276	8.0	19	1
10.0	1337	115	10.0	6	1
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	10028	553	Total	46	3
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	16635	573	4.0	1366	47
6.0	52342	2706	6.0	4297	222
8.0	9759	673	8.0	801	55
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	78737	3952	Total	6464	324
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	6753	233	4.0	877	30
6.0	14272	738	6.0	1853	96
8.0	884	61	8.0	115	8
10.0	0	0	10.0	0	0
15.0	41	5	15.0	5	1
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	21950	1037	Total	2851	135
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	481	17	4.0	37	1
6.0	1851	96	6.0	142	7
8.0	377	26	8.0	29	2
10.0	16	1	10.0	1	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	2725	140	Total	209	11
Annual Total	113441	5681	Annual Total	9570	472

Fundulidae⁶					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	0	0	Total	0	0
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	1	0
4.0	0	0	4.0	9	0
6.0	0	0	6.0	5	0
8.0	0	0	8.0	1	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	2	0
25.0	0	0	25.0	1	0
30.0	0	0	30.0	0	0
Total	0	0	Total	18	1
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	7	0
4.0	0	0	4.0	69	2
6.0	0	0	6.0	7	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	2	0
15.0	0	0	15.0	5	1
20.0	0	0	20.0	56	10
25.0	0	0	25.0	2	1
30.0	0	0	30.0	5	1
Total	0	0	Total	154	15
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	0	0	Total	0	0
Annual Total	0	0	Annual Total	171	16

⁶ The use of Cyprinidae as a surrogate for length class distribution data resulted in some unrealistic fish size estimates. This is due likely to the presence of common carp within the dataset.

Esocidae⁷					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	0	0	Total	0	0
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	0	0	Total	0	0
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	12	0
4.0	0	0	4.0	32	1
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	12	1
15.0	0	0	15.0	0	0
20.0	0	0	20.0	12	2
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	0	0	Total	69	5
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	0	0	Total	0	0
Annual Total	0	0	Annual Total	69	5

⁷ Black Bass used as a surrogate for length class distribution.