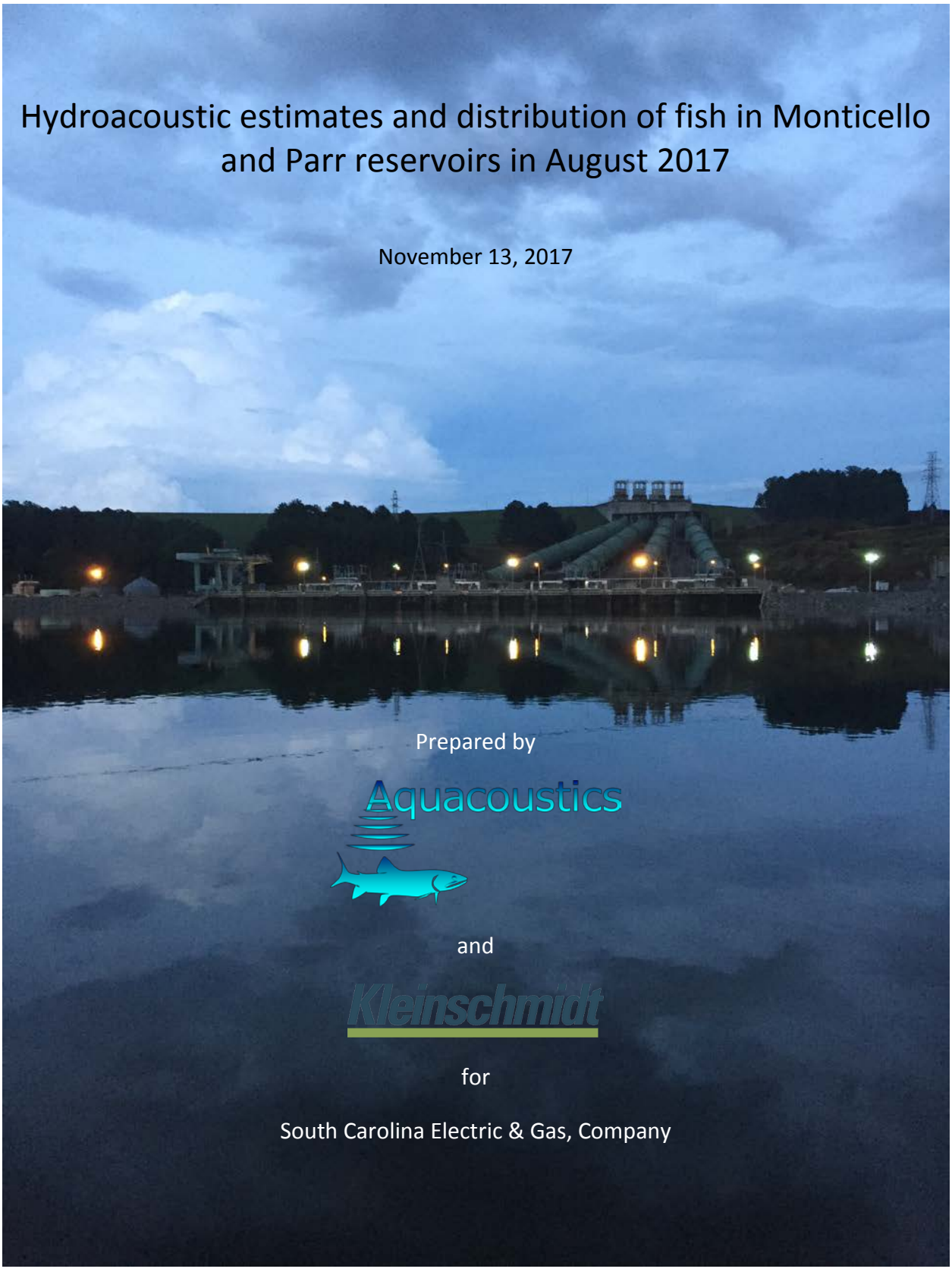
# Hydroacoustic estimates and distribution of fish in Monticello and Parr reservoirs in August 2017

November 13, 2017



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## Introduction

South Carolina Electric & Gas Company (SCE&G) is the Licensee of the Parr Hydroelectric Project (FERC No. 1894) (Project). The Project consists of the Parr Shoals Development and the Fairfield Pumped Storage Development. Both Developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina.

The Parr Shoals Dam forms the 15-mile-long Parr Reservoir along the Broad River. The Parr Development has 6 vertical-shaft Francis turbines with a combined licensed capacity of 14.9 MW. The maximum hydraulic capacity of each turbine is approximately 1,000 cubic feet per second (cfs), and the minimum unit turndown has an estimated flow of 150 cfs. Parr Development typically operates in a modified run-of-river mode and normally operates continuously to pass Broad River flows.

The Fairfield Development is located directly off of the Broad River and uses the 6,800-acre Monticello Reservoir as its upper pool and Parr Reservoir as the lower pool for pumped storage operations. The Fairfield Development has eight vertical-shaft reversible Francis pump turbines. The turbines have a maximum combined licensed capacity of 511.2 MW. The maximum hydraulic capacity of each pump-turbine in generating mode is 6,300 cfs, and the minimum turndown flow is approximately 2,500 cfs. In pumping mode, the turbines each have an average rated hydraulic capacity of 5,225 cfs across the total dynamic head range of 158 to 173 feet. The Fairfield Development is primarily used for peaking operations, reserve generation, and power usage.

The Project is currently involved in a relicensing process which involves a variety of stakeholders including state and federal resource agencies, state and local government, non-governmental organizations (NGO), and interested individuals. SCE&G established several Technical Working Committees (TWC's) comprised of interested stakeholders with the objective of identifying and addressing environmental issues associated with the Project.

As part of this process, the Fisheries TWC requested a desktop fish entrainment and turbine mortality study be conducted as part of relicensing to determine the potential impacts of operating the two Developments on the fisheries communities in Parr and Monticello reservoirs. That study was performed by Kleinschmidt Associates (2015). A recommendation of the study was to identify potential ways to reduce fish entrainment at the Project. The TWC discussed the reduction of lighting at night in each of the intake areas as a potential way to reduce fish entrainment. To evaluate this measure, SCE&G contracted with Aquacoustics, Inc. to perform hydroacoustic evaluations in each of the Fairfield Development intake areas (conventional and pump-back) at night with lights “on” and lights “off” to determine if reduction of lighting in the intake areas could potentially reduce concentration of fish at the intakes and therefore reduce potential fish entrainment.

This report provides a summary of the hydroacoustic study performed by Aquacoustics.

## Methods

Monticello Reservoir and a portion of Parr Reservoir were sampled in August 2017 with a 200-kHz split beam sonar system to estimate the limnetic fish population. The survey goals were:

1. to provide a fish density estimate in Monticello and Parr reservoirs, and
2. to collect fish density data in the Fairfield intake/discharge areas to determine if reduction of lights would reduce fish densities in the intakes.

Sampling for reservoir fish density was conducted in Monticello Reservoir on August 9th after sunset (Figure 1). The Project station did not operate during data collection. Sampling within the Fairfield intake also occurred on August 9th (lights "on") and was concentrated within the intake structure and along the dam on either side of the intake structure (Figure 2). SCE&G originally proposed that data be collected during both lights "on" and lights "off". However, the intake structure was not sampled during a lights "off" condition because there was only a single light in the intake and it did not appear to represent an attraction to fish.

The Fairfield tailwater was sampled on August 10th (lights "on") and 11th (lights "off") after sunset. The Project did not operate during data collection. Sampling in the tailwater included an S-shaped transect from the railroad trestle upstream to the dam face on August 10th, and 3 replicate transects less than 30 meters from the face of the dam from the river-left bank to the river-right bank (Figure 2). Six tailwater lights were lit during the August 10th sampling. The tailwater lights were turned off during sampling on August 11th (Figure 3) when the 3 replicate transects across the face of the dam were re-sampled.

Hydroacoustic data was collected using a Simrad EK60 sonar system with two 7° circular split beam transducers. Sampling and processing parameters are listed in Table 1. The system was calibrated in situ using a standard 36 mm tungsten carbide sphere, and gain corrections were applied to the data during processing to correct the measured sphere acoustic size to the expected value at the water temperature of 30°C. Sampling was conducted after sunset by randomly traversing the limnetic region of the reservoir at a speed of 2.0 - 2.2 meters/sec. The vertically and horizontally aimed transducers were mounted on poles at a depth of 0.5 and 1 meter, respectively. The top 2 meters of the water column was sampled by the horizontally aimed transducer and the remainder of the water column was sampled with the vertically aimed transducer. A Geographic Positioning System (GPS) with Wide Area Augmentation System (WAAS) differential correction fed location information to the system and was written to the acoustic data files.

The data were processed using EchoView software to output total backscatter from fish targets in 1-meter depth strata for each 250-meter longitudinal distance sampled in Monticello Reservoir. For surveys in the vicinity of the Fairfield intake and discharge targets were summed for each 100-meter distance and 1-meter depths , and the Fairfield lights on/lights off survey used 5-meter intervals and 1-meter depths. The echo integration values were scaled using the mean backscatter (TS/Sigma) for an individual

fish for each area and transducer sampled. The lakewide survey on Monticello reservoir also used different scalers by depth strata because fish size varied by depth in the reservoir. Echoview single target criteria are presented in Table 1.

## Results

The lakewide population estimate for Monticello Reservoir is 81,302,857 (Table 2). The lake was stratified into 3 zones for the population estimate; the Upper Lake, Mid-Lake, and the Exclusion Zone (Figure 1). Densities were over 2 times higher in the Upper and Mid-Lake strata than in the Exclusion Zone (Table 2). Densities in the Fairfield intake (Monticello Reservoir) were less than half the densities found in the nearby Exclusion Zone. Densities in the Fairfield discharge (Parr Reservoir) between the dam and the railroad trestle were slightly higher than in the intake area.

The vertical distribution of fish varied by strata with 97% of the fish in the Upper Lake above 10 meters while the Mid-Lake and Exclusion Zone had only 88.3% and 91.8% above 10 meters, respectively (Figure 4). The 10% of the population below 10 meters in the Mid-Lake and Exclusion Zone were also larger fish. Nearly 85% of fish in the top 10 meters were less than 8-cm, while only 50% of the fish below 15 meters were less than 8-cm (Figure 5).

Fish densities measured in and near the Fairfield intake (Monticello Reservoir) structure during lights "on" were lower than in Monticello Reservoir, but the fish were larger (Figure 6). Only 35% of the fish were less than 10-cm and 43% were greater than 30-cm. These larger fish are likely not as susceptible to entrainment because they likely can escape the water velocities produced by generation, but may be in the area to prey upon smaller fish entrained during pump operations.

Sampling the Fairfield discharge (Parr Reservoir) indicated that lights on the dam face were attracting fish to the structure when the hydro was not pumping. We saw a mean density of 12,946 fish/hectare near the face of the structure when the lights were on, but only 3,980 fish/hectare the following night when the lights were off. Fish were also distributed near surface and the lights (Figure 7).

## Conclusions

We can make two general remarks based on these hydroacoustic surveys at the Fairfield Project.

The lake-wide estimates on Monticello Reservoir were performed during the time of year that the highest fish (especially shad) densities are expected to be observed. Estimates in the late fall, winter, and early summer would better define the fish densities susceptible to entrainment during other portions of the year. Monthly surveys at other hydroelectric project (Lake Norman and Thurmond Lake) tailwater areas indicate that shad populations decline through the fall (threadfin shad die-off in December or January with colder water

temperatures) and shad recruitment occurs in June, so potential entrainment should oscillate during the year as densities in the reservoir and tailwater change.

Based on our observations, it is reasonable to conclude that lighting reduction in the Fairfield discharge (Parr Reservoir) should reduce the concentration of fish in the immediate intake area. This reduction could reduce the potential of fish entrainment at pump back start up and during some pumping events in that area of the Project.

## Protection, Mitigation, Enhancement Measure Recommendation

As a protection and reduction measure for fish entrainment at the Fairfield Development, SCE&G recommends that the Fairfield Development tailrace lights (the lights that are located on the powerhouse intake and shine onto the tailrace intake area) will be turned off under normal operating conditions. The lighting reduction should provide a reduction in future entrainment at the Fairfield Development.

However, should the Department of Homeland Security National Terrorism Advisory System (or an equivalent program) or other law enforcement agency determine that the security threat level should be elevated, these lights may be turned on and may stay on as long as an elevated security threat level is in place. Lights will be turned off again after the threat level is lowered to normal levels.

Table 1. Hydroacoustic data collection and processing parameters.

| **Sampling Parameter** | **Setting** |
|---|---|
| Power | 60 W |
| Pulse duration | 256 µsec |
| Ping rate | 5/sec |
| | |
| **Processing Parameter** | |
| Minimum threshold | -60 dB |
| Minimum TS threshold | -60 dB |
| Sound speed | 1509 m/sec |
| Absorption coefficient | 0.006622 |
| | |
| **Single target detection** | |
| TS threshold | -60 dB |
| Pulse length determination level | 6 dB |
| Min normalized pulse length | 0.5 |
| Max normalized pulse length | 1.5 |
| Beam compensation | Simrad LOBE |
| Max beam compensation | 12 dB |
| Max STD minor angle | 0.6 |
| Max STD major angle | 0.6 |

Table 2. Fish density estimates by strata with area for each strata and population estimates with 95% confidence limits.

| Strata | Area (ha) | Density (#/ha) | Estimate | Lower 95% | Upper 95% |
|---|---|---|---|---|---|
| **Monticello Lake** | | | | | |
| Upper Lake | 835 | 42,347 | 35,346,124 | 26,855,930 | 46,143,995 |
| Mid-Lake | 1407 | 29,296 | 41,223,193 | 30,555,188 | 54,233,970 |
| Exclusion Zone | 332 | 14,254 | 4,733,540 | 3,882,570 | 5,629,847 |
| Total | | 28,962 | 81,302,857 | 61,293,689 | 106,007,812 |
| **Fairfield** | | | | | |
| Fairfield intake (Monticello Res.) | 1.5 | 5,835 | 8,753 | 5,586 | 14,242 |
| Fairfield discharge (Parr Res.) | 24.55 | 7,308 | 179,401 | 135,433 | 228,495 |

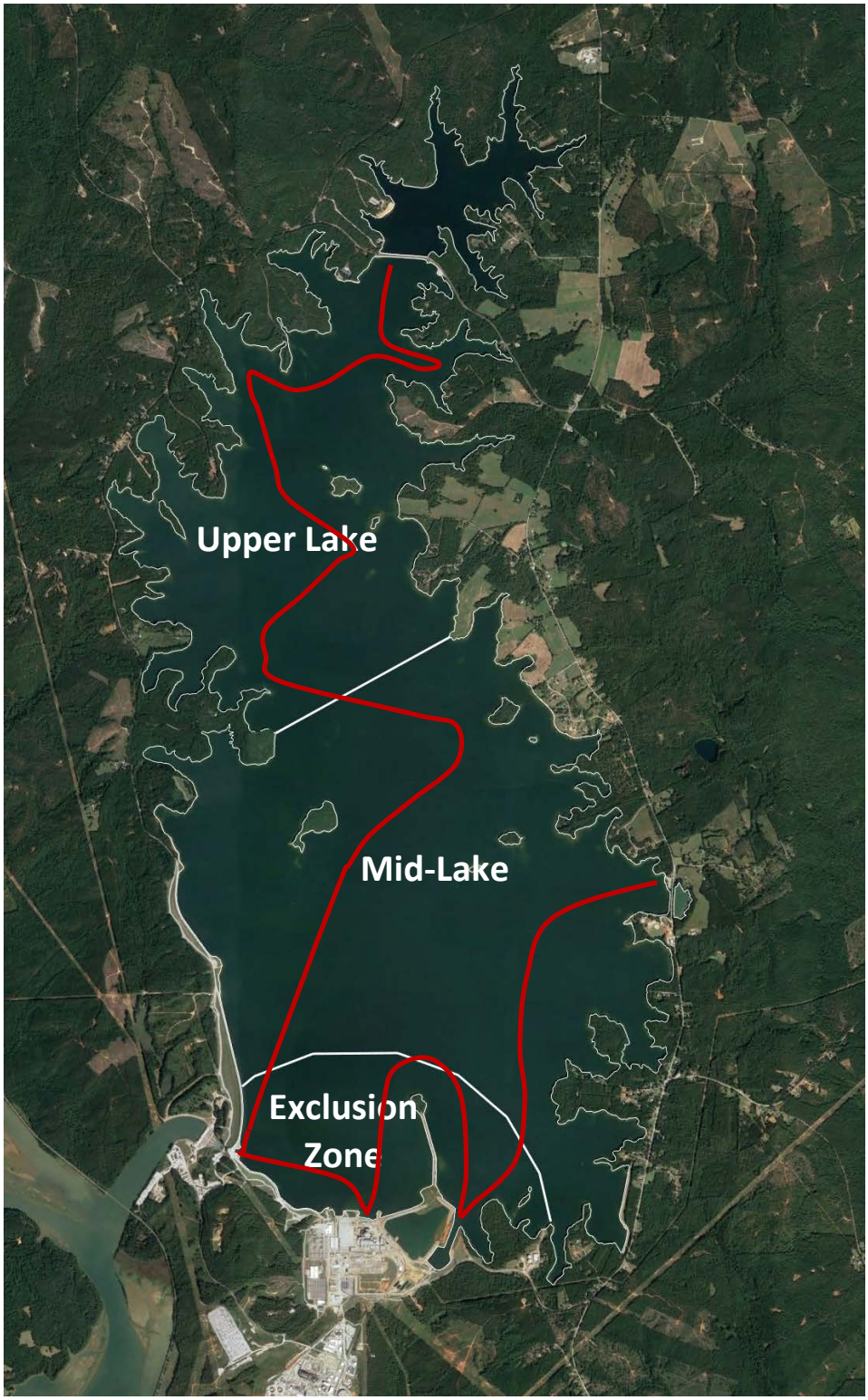


Figure 1. Map of Monticello Reservoir with transect line (red) and zones sampled using hydroacoustics.

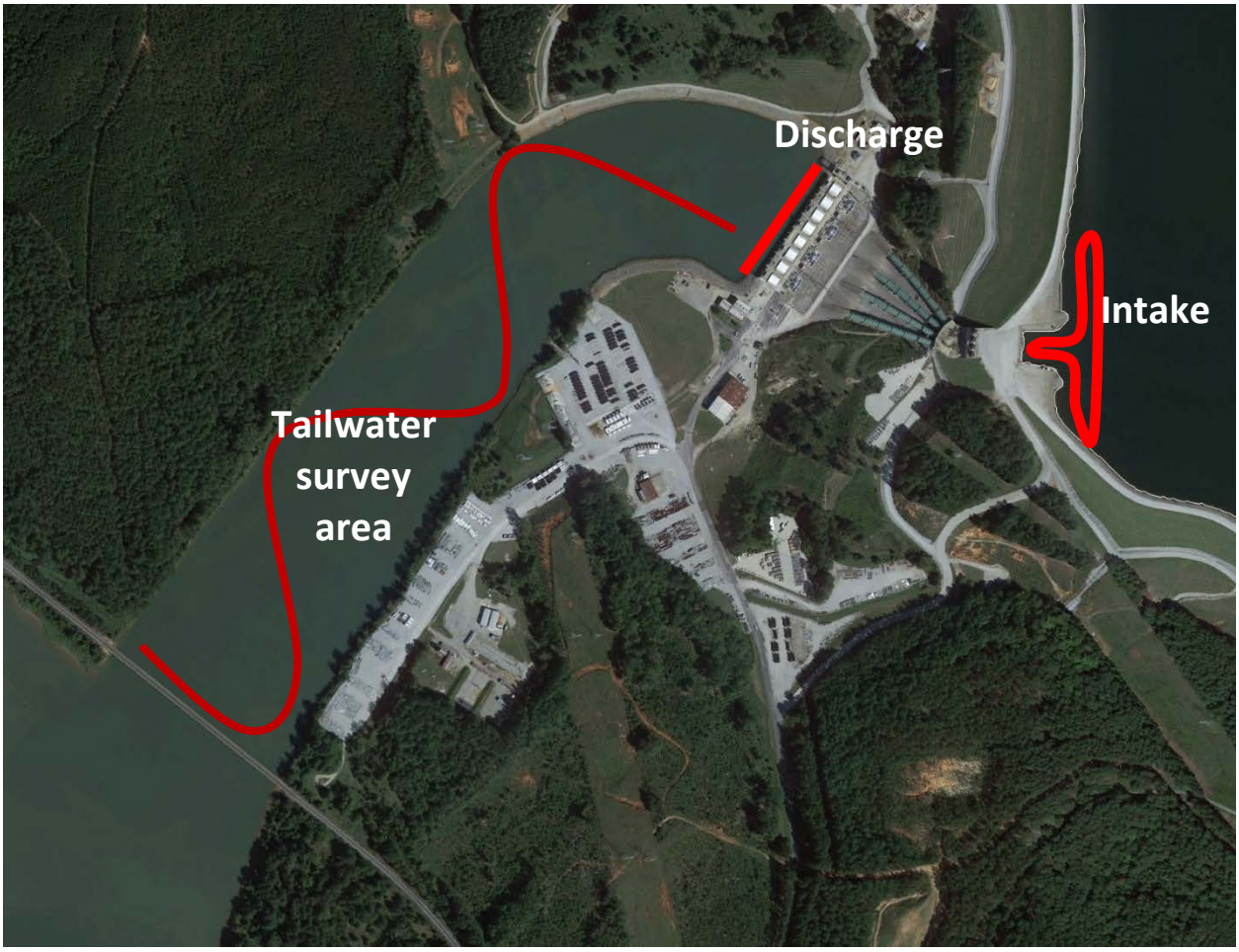


Figure 2. Map of intake, discharge, and tailwater areas sampled with hydroacoustics.

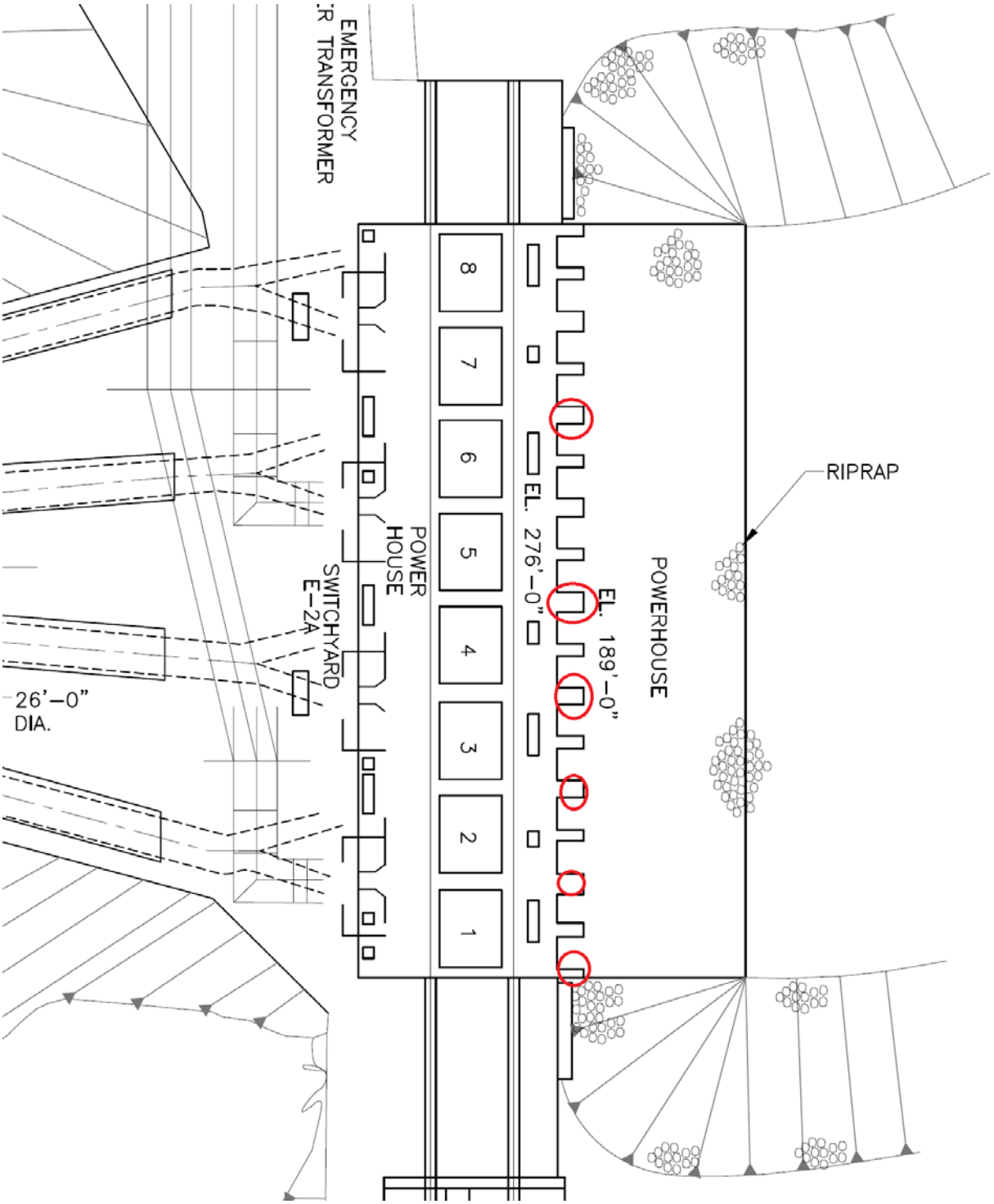


Figure 3. Diagram of Fairfield discharge with locations of lights indicated with red circles.

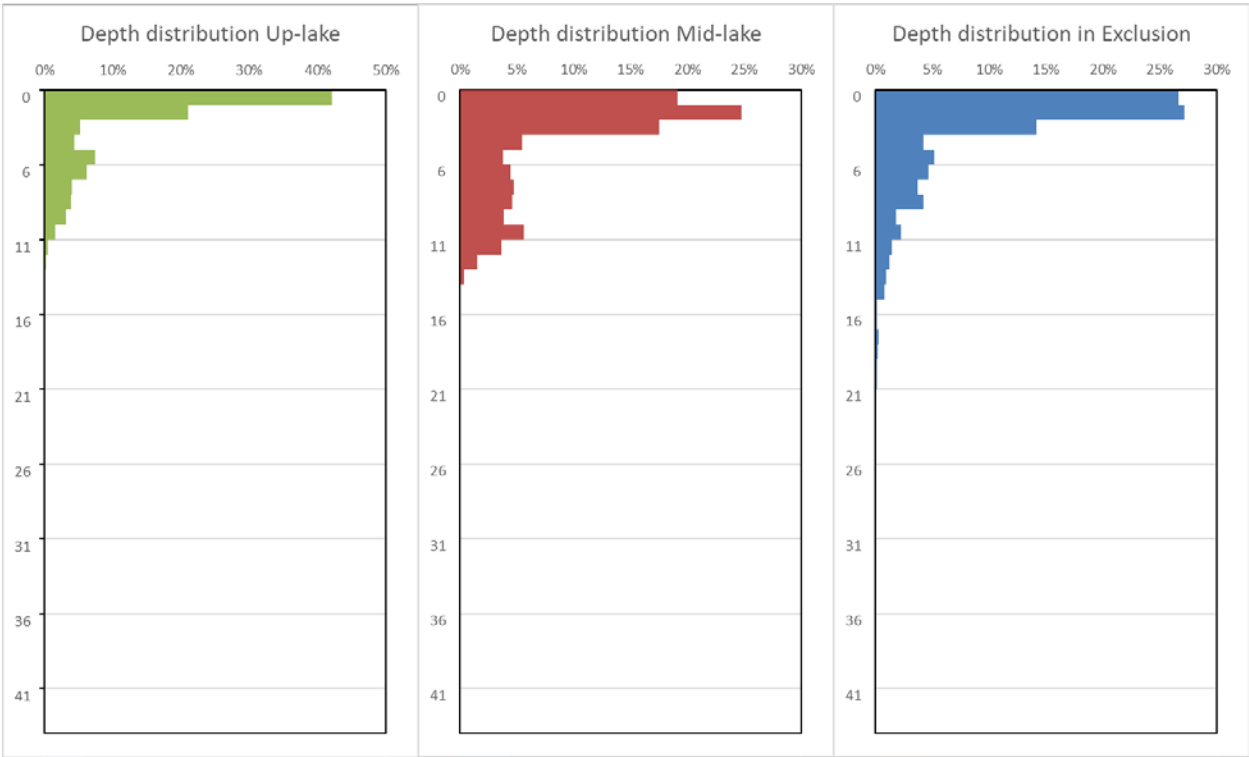


Figure 4. Vertical distribution of fish in the 3 sample strata.

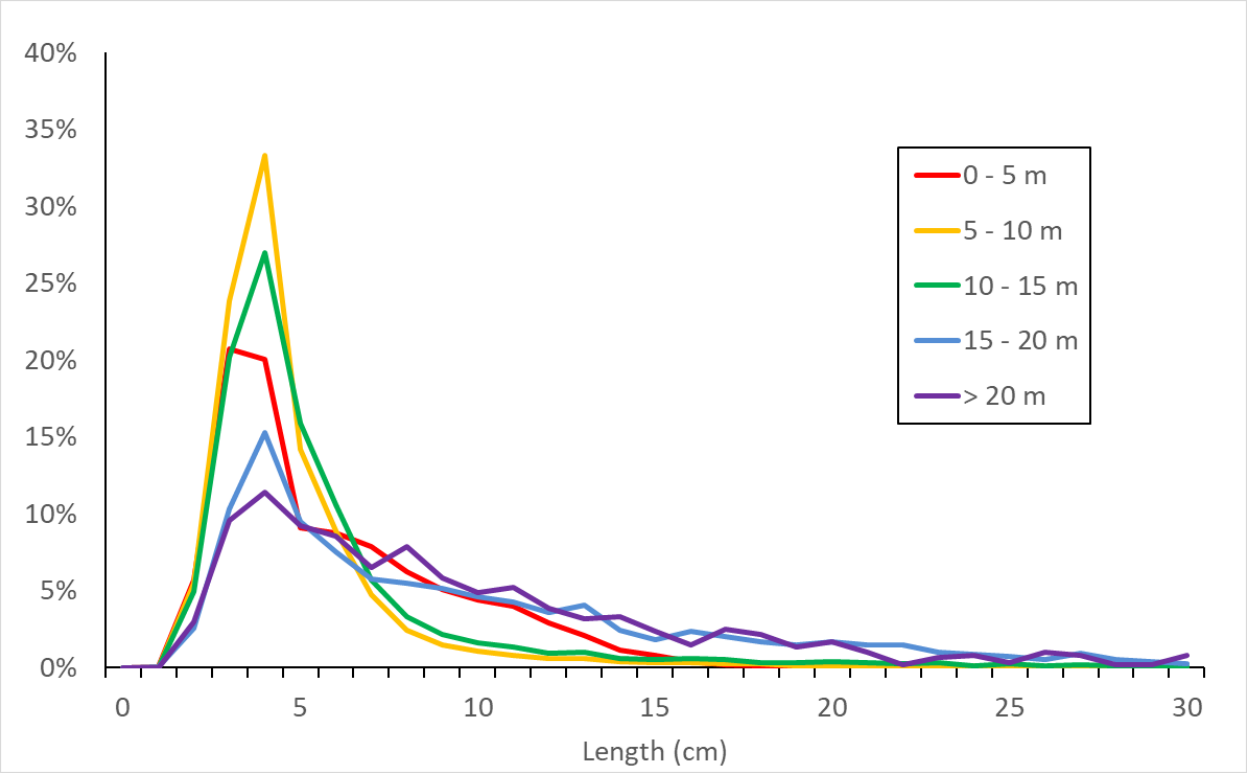


Figure 5. Length frequency of fish targets in Monticello Reservoir by depth strata. Acoustic size converted to fish length using Loves dorsal aspect equation.

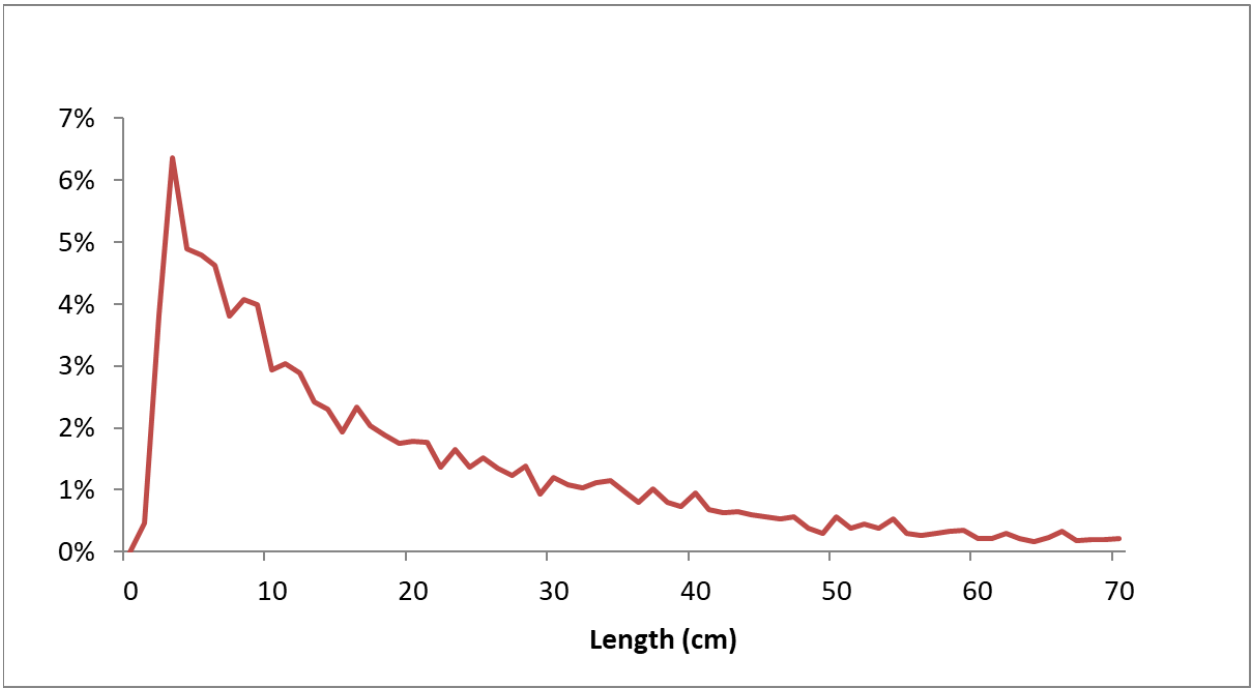

Figure 6. Length frequency distribution of fish in the Fairfield intake. Acoustic size converted to fish length using Loves dorsal aspect equation.

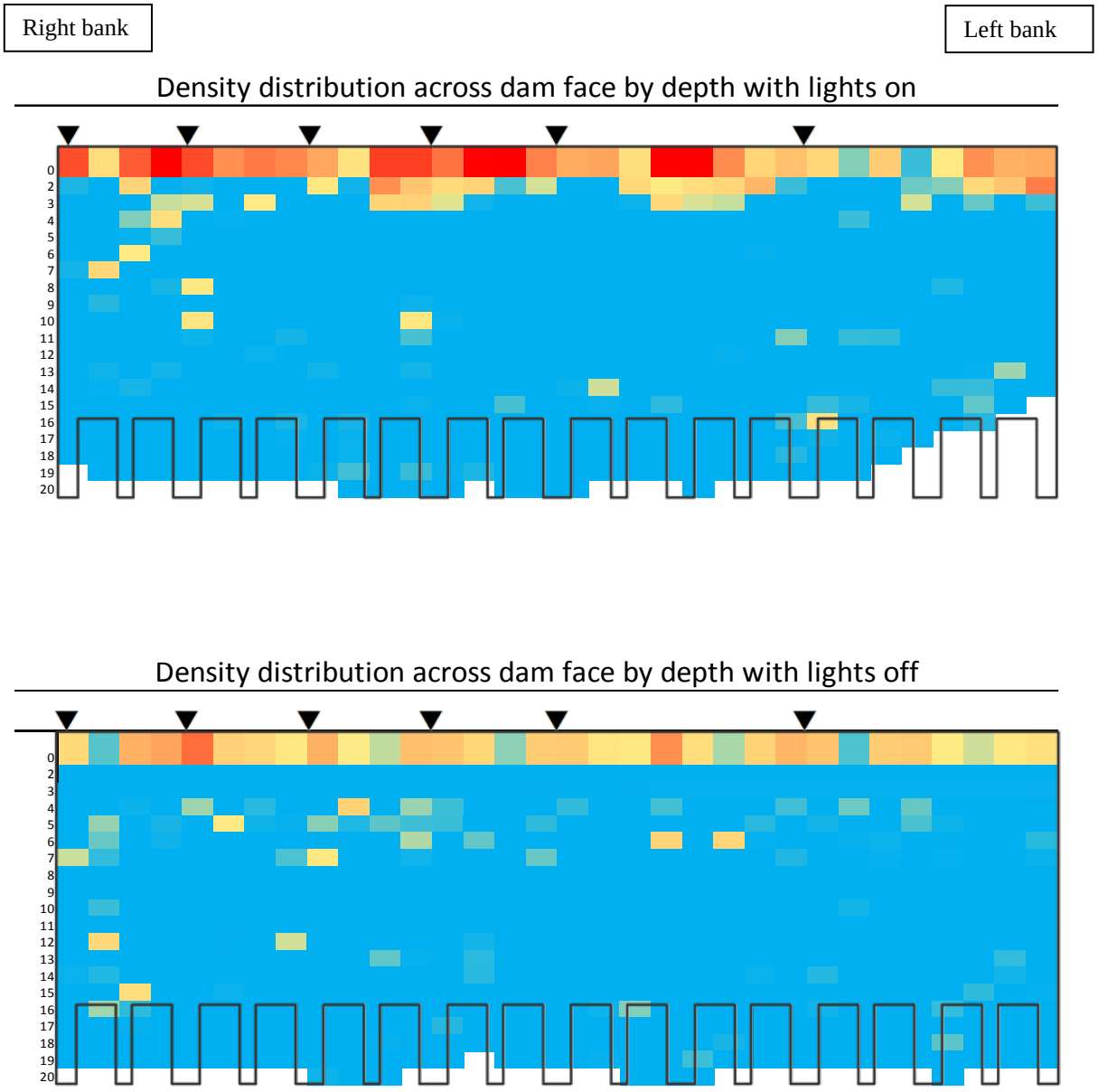


Figure 7. Density distribution of fish in the Fairfield tailrace near the dam on August 10 and 11 when the lights were "on" and "off", respectively. Graphic shows distribution across the face of the dam from top to bottom. Hot colors indicate higher densities and cooler colors show low densities. White indicates no data. Black triangles near surface indicate the location of the lights that were on during sampling, and the intake bays are near bottom at 16 to 20 meters deep.