

**SUMMARY OF OPERATIONS AT THE
CONOWINGO DAM EAST FISH PASSAGE FACILITY
SPRING 2016**

November 2016

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Prepared for

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EXECUTIVE SUMMARY

Operation of the Conowingo East Fish Lift (EFL) began April 1, 2016 as the water temperature was above the season start trigger value of 50°F (56.9°F actual average EFL trough water temperature on April 1) and river flow was 25,900 cfs. The first fourteen American shad were passed on the initial day of operation. The EFL operated for 55 days in 2016; alternate day operation from April 1 through April 19, then everyday operation from April 20 through June 3. EFL operation was terminated after facility shutdown on June 3 in concurrence with the Resource Agencies. The 2016 fish passage season was not interrupted by any high river flow events or extreme increases to water temperature as was experienced in 2015. The 2016 fish passage season marks the twenty-sixth season of overall operation and the twentieth year of volitional fish passage at the Conowingo EFL.

The EFL passed 865,179 fish of 27 species and two hybrids. Gizzard shad (833,681), American shad (14,276), white perch (6,544), and channel catfish (3,414) dominated the catch, and comprised 99% of the total fish collected and passed. Gizzard shad alone accounted for 96% of the total fish collected and passed.

A total of 14,276 American shad was passed. The highest daily passage of American shad occurred on April 21 when 1,487 shad were passed upstream. On 3 of the 55 days of operation, American shad passage exceeded 1,000 fish. On a daily basis, overall shad passage was strongest through the fishway between 1500-1759 hours during which 49% of all shad passage occurred.

Fishway operations were conducted at water temperatures ranging from 49.8°F to 80.7°F and river flows between 17,900 and 55,800 cfs. High river flow events did not occur in 2016 allowing the EFL to operate uninterrupted throughout the entire migratory fish passage season.

Prior to the start of EFL operations in 2016, routine pre-season maintenance activities were conducted and included testing of the fish collection equipment (crowder, crowder screen hoist, hopper hoist motor, and hopper door along with inspection of associated air hoses, pneumatic cylinders, etc.). These pre-season maintenance activities along with routine maintenance performed during the season resulted in a minimal loss of fishing time (3.5 hours) due to any mechanical failures throughout the entire fish passage season.

On 49 of the 55 days of operation, water clarity was excellent (20 -36 inches of visibility at viewing window), allowing the viewing technicians to identify American shad with attached Maryland DNR floy tags. The number of floy tags observed at the Conowingo EFL in 2016 was 42, (39 orange = 2016 effort; 3 blue = 2015 effort).

Future operations of the EFL will build on the past twenty-six years of operation experience.

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1.0 INTRODUCTION

Exelon Generation Company, LLC, formerly the Susquehanna Electric Company (SECO), has operated a fish passage facility (West lift) at its Conowingo Hydroelectric Station since 1972. Lift operations are part of a cooperative private, state, and federal effort to restore American shad (*Alosa sapidissima*) and other migratory fishes to the Susquehanna River. In accordance with the restoration plan, the operational goal had been to monitor fish populations below Conowingo Dam and transport pre-spawned migratory fishes upriver.

In 1988, the former PECO Energy Company negotiated an agreement with state and federal resource agencies and private organizations to enhance restoration of American shad and other anadromous species to the Susquehanna River. A major element of this agreement was for PECO Energy Company to construct an East Fish Lift Passage Facility (EFL) at Conowingo Dam. Construction of the EFL commenced in April 1990 and it was operational by spring 1991.

With the completion of fishways at Holtwood, Safe Harbor, and York Haven dams, the EFL has been operated to pass fish directly into Conowingo Pond since spring 1997.

Objectives of 2016 operation were: (1) monitor passage of migratory and resident fishes through the fishway; (2) assess fishway and trough effectiveness and make modifications as feasible and (3) assist the Holtwood hydro station with their Tier I study by providing American shad from the EFL trough for PIT tagging efforts.

2.0 CONOWINGO OPERATION

2.1 Project Operation

The Conowingo Hydroelectric Station, built in 1928, is located at river mile 10 on the Susquehanna River (RMC 1992). The powerhouse has a peaking generating capacity of 549.5 MW and a hydraulic capacity of approximately 85,000 cfs. Flows in excess of station draft are spilled through two regulating and 50 crest gates. The powerhouse contains seven vertical Francis (numbered 1 through 7) and four Kaplan (numbered 8 through 11) turbines. The seven Francis units have been equipped with aeration systems that permit a unit to draw air into the unit (vented mode) or operate conventionally (unvented mode). The four original Kaplan turbines installed in 1964 were replaced over a period of four years (1992 to 1996), with more efficient mixed-flow Kaplan type turbines.

Minimum flow releases from the station during the spring spawning and fishway operating season follow the schedule outlined in the settlement agreement. Minimum flows of 10,000 cubic feet per second (cfs) or natural river flow, whichever is less, as measured at the United States Geological Survey (USGS) gauge at Marietta, PA were maintained for the period 1 to 30 April. A minimum flow of 7,500 cfs or natural river flow (as previously noted) was maintained for the period 1 to 31 May. A minimum flow of 5,000 cfs or natural river flow (as previously noted) is maintained when fish lift operations occur in June.

2.2 Fishway Operation

The start of operation for the EFL in 2016 began on April 1, 2016, resulting in the passage of 14 American shad (Table 1). The EFL operated for 55 days in 2016 with alternate day operation occurring from April 1 through April 19. Continuous operation of the EFL occurred from April 20 through June 3 when operations were terminated in concurrence with the Resource Agencies.

Daily operation times were planned during optimal fish passage parameters. This year, operational methodologies were influenced by natural river flow, water temperature, station generation, and daily/hourly fish passage numbers. EFL operation was conducted by a staff of three personnel: a lift operator, a supervising biologist, and a biological technician.

The mechanical aspects of EFL operation in 2016 were similar to those described in RMC (1992) and Normandeau Associates, Inc. (1999). Fishing time and/or lift frequency was determined by fish abundance, but the hopper was generally cycled twice per hour throughout the day. The method of lift operation was also influenced by fish abundance. When a large number of fish were in the fishing channel, the crowder was not operated; instead the crowder screen was raised and then lowered, trapping fish over the hopper. This mode of operation, called "fast fish", involved leaving the crowder in the normal fishing position and raising the hopper frequently to remove fish that accumulated in the holding channel.

The specific entrance(s) used to attract fishes was dictated by the station discharge and which turbine units were operating. For example, when Kaplan turbine units 8, 9, 10, and 11 or any combination of Kaplan turbines were operating, entrance C was the primary entrance used to attract fishes. Under these conditions the attraction flow through the other entrances is negated or disrupted. Depending on river flow and/or generation, either entrance A or C was utilized throughout the 2016 season to attract fishes.

2.3 Fish Counts

Fish that were lifted and sluiced into the trough were guided by a series of fixed screens. The fixed screens directed the fish to swim up and through a 3 ft wide channel and past a 4 ft by 10 ft counting window located on the west wall of the trough. Fish passing the counting window were identified to species and enumerated by a biologist and/or technician. Passage of fish by the window and out of the trough system was controlled by a set of gates located downstream of the counting window. During periods of peak passage, two people were used to identify and count fish.

At the end of each hour, fish passage data were recorded on data sheets and entered into a Microsoft Excel worksheet on a Personal Computer. Data processing and reporting were PC based and accomplished by program scripts, or macros, created within Microsoft Excel software. After the technician verified the correctness of the raw data, a daily summary of fish passage was produced and distributed electronically to plant personnel. Each day's data were backed up and stored off site. Daily reports and weekly summaries of fish passage were electronically distributed to plant personnel and other cooperators.

3.0 RESULTS

3.1 Relative Abundance

The number of fishes collected and passed by the Conowingo Dam EFL is presented in Table 1. A total of 865,179 fish of 27 species and two hybrids passed upstream into Conowingo Pond. Gizzard shad (833,681), American shad (14,276), white perch (6,544), and channel catfish (3,414) dominated the catch, and comprised 99% of the total fish collected and passed. Gizzard shad alone accounted for 96% of the total fish collected and passed. Peak passage occurred on April 25 when 38,051 fish, (99% gizzard shad), were passed.

3.2 American Shad Passage

The EFL collected and passed 14,276 American shad (Table 1). The first 14 American shad passed on April 1 (initial day of operation). Collection and passage of shad varied daily with 3.8% (539) of the shad passed from April 1 to April 20, 55.1% (7,866) passed from April 21 to May 10, and 41.1%

(5,871) passed from May 11 to June 3, (Figures 1 and 2). On 3 of the 55 days of operation, American shad passage exceeded 1,000 fish. The largest number of American shad passed at the EFL in 2016 occurred on April 21 (1,487).

American shad were collected and passed at water temperatures ranging from 54.0°F to 80.7°F and river flows between 17,900 and 55,800 cfs (Table 2, and Figure 1). The average daily river flow on the 3 days when American shad passage exceeded 1,000 fish ranged between 22,100 cfs and 31,100 cfs. The average daily river flow during the operational season was 32,942 cfs.

The hourly passage of American shad at the EFL is provided in Table 3. On a daily basis, overall shad passage was strongest through the fishway between 1500 hours and 1759 hours during which 49% of the total American shad passage occurred. The highest hourly passage rate occurred from 1700 to 1759 hours. The highest number of American shad passed in one hour (468) occurred from 1500 to 1559 hrs on April 21.

3.3 Gizzard Shad Passage

The EFL collected and passed 833,681 Gizzard shad in 2016 (Tables 1 and 4). Gizzard shad accounted for 96% of the total fish collected and passed. On 3 of 55 days of operation, Gizzard shad passage exceeded 35,000 fish. Gizzard shad passage exceeded 30,000 and 20,000 fish on 1 and 13 days, respectively. Table 4 provides the ratio of American shad to Gizzard shad for the years of volitional passage (1997-2016). In years when American shad passage exceeds 50,000 fish, the ratio ranges from 1:2 – 1:14 (Am. shad/gizzard shad). For those years when American shad passage is less than 50,000 fish, the ratio ranges from 1:16 – 1:112. The year 2011 is an exception to this because of the agency requested shutdown on May 19, 2011 which ended EFL operations earlier than previous years.

3.4 Alosids

A small number of Blueback herring, (34) were passed during the 2016 season. No Alewife or Hickory shad were passed in spring 2016.

3.5 Maryland tag-recapture

During the 2016 season, the EFL passed American shad that were captured, floy-tagged and released downstream of Conowingo dam by the Maryland DNR. This year, the Maryland DNR tagged a total of 367 American shad. The number of floy tags observed at the Conowingo EFL in 2016 was 42; 39 orange tags (2016 effort) and 3 blue tags (2015 effort).

4.0 SUMMARY

EFL operation was initiated on April 1 as river water temperature was above 50°F (56.9°F) and river flow was 25,900 cfs. The first 14 American shad passed on this initial day of operation. The EFL passed 14,276 American shad from April 1 through June 3. The total number of American shad passed during the 2016 season was nearly 6,000 more shad than observed in 2015, possibly due to the lower average daily river flows and water temperatures that remained below 70.0° F until May 26. These two conditions may have provided a larger window of opportunity for the EFL to collect and pass more American shad this season than in 2015 when the river water temperature first

exceeded 70.0° F on May 9. The low river flows allowed for uninterrupted operation of the EFL for 55 days, resulting in 9 additional days, 103 more operating hours, and 186 more lifts conducted this season than in 2015. This year marks the fourth consecutive year in which the EFL passed less than 15,000 American shad.

Modifications made to the fish trough, particularly the valve grating and hopper trough chute since 1999 have diminished the potential for the valve grating to clog with various types of debris and have decreased the number of American shad lift mortalities observed throughout the last several fish passage seasons. Since the valve grating was modified prior to the start of the 2000 season, loss of water flow in the trough has not occurred, particularly during high river flow periods when large amounts of debris may enter the trough through the fish exit area. An aeration system was also installed prior to the 2000 passage season to diminish low dissolved oxygen levels when the American shad population is heavy in the trough. Prior to fishway operations in 2002, a 30 inch diameter fiberglass elbow was attached to the hopper extension chute, which had been installed in 2001. The modification allows fish to enter the trough center stream, instead of being directed toward the east trough wall. A decrease in lift mortalities has also been observed since the fiberglass elbow was installed. A total of 297 American shad lift mortalities that did not contain PIT tags from the Holtwood fish passage efficiency study, (2.0% of the total shad passed), was observed in 2016, lower than the value observed in 2015 (2.9%), and less than values observed during the 1991 through 1996 trap and transport operations (1.5% to 10.5%).

Prior to the start of EFL operations in 2016, routine preseason maintenance activities were conducted, and included testing of the fish collection equipment (crowder, crowder screen hoist, hopper hoist motor, and hopper door along with inspection of associated air hoses, pneumatic cylinders, etc.). These maintenance activities, along with routine maintenance activities performed in season resulted in only 3.5 hours of lost fishing time due to the repair, replacement, and calibration of limits for the crowder area gate and entrance gate C on the morning of May 10.

5.0 RECOMMENDATIONS

- 1) Continue to operate the EFL at Conowingo Dam per annual guidelines developed and approved by the Susquehanna River Technical Committee. Lift operation should adhere to the guidelines; however, flexibility must remain with operating personnel to maximize fishway performance and fish passage.
- 2) Continue the use of two fish counters during periods of increased fish passage to accurately reflect the number of fish that pass through the EFL.
- 3) Continue to inspect cables, limit switches, and lift components to enhance season operability, and continue to evaluate effectiveness of fish trough and hopper door modifications.

6.0 LITERATURE CITED

RMC. 1992. Summary of the operations of the Conowingo Dam fish passage facilities in spring 1991. Prepared for Susquehanna Electric Company, Darlington, MD.

Normandeau Associates, Inc. 1999. Summary of the operations at the Conowingo Dam East fish passage facility in spring, 1998. Prepared for Susquehanna Electric Company, Darlington, MD.

TABLES AND FIGURES

Table 1
Summary of the daily number of fish passed by the Conowingo Dam East Fish Passage Facility in 2016.

Date	4/1	4/2	4/3	4/4	4/5	4/6	4/7	4/8	4/9	4/10	4/11
Start Fishing Time	8:30	9:00	9:00	8:30	8:30	8:00	8:00	8:00	8:00	8:00	8:00
End Fishing Time	16:30	16:30	16:30	16:30	16:30	16:00	16:00	15:30	15:30	15:30	15:30
Elapsed Fishing Time	8.0	7.5	7.5	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5
Viewing Hours	7.8	6.8	6.8	7.1	7.1	8.0	8.0	7.5	7.5	8.0	8.0
Lifts Per Day	16	14	14	13	13	15	15	9	9	7	7
Water Temperature (°F)*	56.9	57.8	56.1	54.6	54.1	53.2	54	53.8	52.8	49.9	50.7
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0
AMERICAN SHAD	14	7	7	2	2	3	3	0	0	0	0
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	0	0	0	0	0
ALEWIFE	0	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	13,240	14,233	14,233	13,436	13,436	6,815	6,815	551	551	1,613	1,613
RAINBOW TROUT	0	0	0	0	0	0	0	0	0	0	0
BROWN TROUT	0	0	0	0	0	0	0	0	0	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0	0
TIGER MUSKY	0	0	0	0	0	0	0	0	0	1	1
CARP	0	0	0	0	0	0	0	0	0	0	0
SPOTTAIL SHINER	3	0	0	0	0	0	0	0	0	0	0
QUILLBACK	0	0	0	0	0	0	0	0	0	0	0
WHITE SUCKER	1	1	1	0	0	0	0	0	1	0	0
SHORTHEAD REDHORSE	1	0	0	0	0	0	0	0	0	0	0
YELLOW BULLHEAD	0	0	0	0	0	0	0	0	0	0	0
BROWN BULLHEAD	0	0	0	0	0	0	0	0	0	0	0
CHANNEL CATFISH	0	1	1	6	6	0	0	0	0	0	0
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0	0
WHITE PERCH	0	0	0	0	0	0	0	0	0	0	0
STRIPED BASS	0	0	0	0	0	0	0	0	0	0	0
STRIPED BASS HYBRID	0	0	0	0	0	0	0	0	0	0	0
ROCK BASS	0	0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	0	0
BLUEGILL	0	0	0	2	2	1	1	0	0	0	0
SMALLMOUTH BASS	2	0	0	0	0	1	1	0	0	0	0
LARGEMOUTH BASS	0	0	0	1	1	0	0	0	0	0	0
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0	0
WALLEYE	0	0	0	0	0	0	0	0	0	0	0
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	1	0	0	1	1	1	1	0	0	0	0
Total	13,262	0	14,242	0	13,448	0	6,821	0	552	0	1,614

Table 1 (continued)

Date	4/12	4/13	4/14	4/15	4/16	4/17	4/18	4/19	4/20	4/21	4/22
Start Fishing Time	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00
End Fishing Time	15:30	16:00	16:00	16:00	16:00	16:00	16:00	16:00	18:00	18:00	17:40
Elapsed Fishing Time	7.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	10.0	10.0	9.7
Viewing Hours	7.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	10.0	10.1	10
Lifts Per Day	10	10	11	10	11	11	10	10	18	19	15
Water Temperature (°F)	50.9	49.8	49.7	52.2	52.5	54.9	56.9	58.9	59.6	61.3	63.1
AMERICAN EEL	0	0	0	0	0	0	0	2	0	0	0
AMERICAN SHAD	0	0	0	0	0	2	54	54	457	1,487	91
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	0	0	0	0	0
ALEWIFE	0	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	311	4,271	10,702	17,040	14,178	35,421	18,550	17,040	14,178	35,421	18,550
RAINBOW TROUT	0	1	0	0	0	0	0	0	0	0	1
BROWN TROUT	0	0	0	0	0	0	1	1	1	0	1
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0	0
TIGER MUSKY	0	0	0	0	0	0	0	0	0	0	0
CARP	0	0	0	0	0	0	0	0	3	0	0
SPOTTAIL SHINER	0	0	0	0	0	0	0	0	0	0	0
QUILLBACK	0	0	0	0	0	0	1	1	0	2	2
WHITE SUCKER	0	0	2	0	0	0	1	1	0	0	0
SHORTHEAD REDHORSE	0	9	23	43	5	12	6	43	5	12	6
YELLOW BULLHEAD	0	0	0	0	0	0	0	0	0	0	0
BROWN BULLHEAD	0	0	0	0	0	0	0	0	1	2	1
CHANNEL CATFISH	0	1	6	6	7	8	2	6	7	8	2
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	1	0
WHITE PERCH	0	0	0	0	0	0	0	0	0	0	0
STRIPED BASS	0	0	0	0	0	0	0	0	0	1	2
STRIPED BASS HYBRID	0	0	0	0	0	0	0	0	0	0	0
ROCK BASS	0	0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	0	0
BLUEGILL	0	1	0	1	0	0	0	1	0	0	0
SMALLMOUTH BASS	0	0	10	37	19	61	10	37	19	61	10
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	0	0	2
YELLOW PERCH	0	0	0	0	0	0	0	0	0	2	0
WALLEYE	0	0	1	2	1	0	0	0	4	9	5
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	0	0	0	0	0	0	0	0	1
Total	0	311	0	4,285	0	10,746	0	17,186	14,675	37,006	18,674

Table 1 (continued)

Date	4/23	4/24	4/25	4/26	4/27	4/28	4/29	4/30	5/1	5/2	5/3
Start Fishing Time	8:00	8:00	8:00	8:30	8:30	8:00	8:00	8:00	8:00	8:00	8:00
End Fishing Time	17:40	17:40	17:40	18:40	17:30	19:00	18:00	18:00	19:00	19:00	18:00
Elapsed Fishing Time	9.7	9.7	9.7	10.2	9.0	11.0	10.0	10.0	11.0	11.0	10.0
Viewing Hours	10.0	10.0	10.0	10.5	9.5	11.0	10.0	10.0	11.0	11.1	10.5
Lifts Per Day	18	18	18	18	15	19	16	17	21	18	20
Water Temperature (°F)	64.5	64.1	65.4	66.6	67.1	66.4	64.9	64.1	63.7	64	64.7
AMERICAN EEL	1	0	0	0	1	0	0	0	0	0	0
AMERICAN SHAD	799	188	26	682	155	1,042	218	213	1,398	753	209
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	2	0	1	0	0
ALEWIFE	0	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	18,251	22,414	37,764	21,601	17,572	31,848	13,567	20,123	13,803	36,022	17,691
RAINBOW TROUT	0	1	0	0	1	0	0	1	0	3	1
BROWN TROUT	0	0	0	0	0	0	1	0	2	1	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0	0
TIGER MUSKY	0	0	0	0	0	0	0	0	0	0	0
CARP	2	0	1	1	0	0	2	2	0	12	1
SPOTTAIL SHINER	0	0	0	0	8	0	0	0	0	0	0
QUILLBACK	6	1	3	18	11	16	11	72	11	7	0
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	0
SHORTHEAD REDHORSE	45	9	132	18	7	51	54	99	4	37	8
YELLOW BULLHEAD	0	0	0	0	0	0	1	0	0	0	0
BROWN BULLHEAD	67	6	75	94	97	183	105	1	62	110	57
CHANNEL CATFISH	19	10	15	10	10	42	32	4	9	16	49
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0	0
WHITE PERCH	0	0	0	0	0	1	4	2	0	0	0
STRIPED BASS	1	4	2	4	1	2	5	4	3	8	2
STRIPED BASS HYBRID	0	0	0	0	0	0	1	0	0	0	0
ROCK BASS	0	0	0	0	0	0	0	0	0	0	0
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	0	0
BLUEGILL	2	1	0	0	4	2	0	0	0	0	1
SMALLMOUTH BASS	27	10	22	6	18	18	12	9	1	4	10
LARGEMOUTH BASS	0	0	0	3	0	1	0	0	0	0	0
YELLOW PERCH	0	0	0	0	0	1	0	1	1	1	0
WALLEYE	4	1	10	1	4	16	20	2	1	2	2
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	1	1	1	1	3	2	2	0	3	0	0
Total	19,225	22,646	38,051	22,439	17,892	33,225	14,037	20,533	15,299	36,976	18,031

Table 1 (continued)

Date	5/4	5/5	5/6	5/7	5/8	5/9	5/10	5/11	5/12	5/13	5/14
Start Fishing Time	8:00	8:00	8:00	8:00	8:00	8:00	11:30	8:00	8:00	8:00	8:00
End Fishing Time	18:50	17:45	17:45	18:00	18:00	17:40	17:40	18:30	18:00	18:40	18:10
Elapsed Fishing Time	10.8	9.8	9.8	10.0	10.0	9.7	6.2	10.5	10.0	10.7	10.2
Viewing Hours	11.0	10.0	10.0	10.0	10.0	10.0	10.0	11.0	10.0	11.0	10.3
Lifts Per Day	17	15	14	18	17	13	10	18	19	18	20
Water Temperature (°F)	63.2	60.3	59.1	59.5	59.4	59.4	59.4	60	61.4	62	62.7
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	1
AMERICAN SHAD	132	22	8	159	46	210	28	172	77	867	508
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	0	3	0	0	1
ALEWIFE	0	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	22,341	25,206	17,437	17,033	26,456	21,606	12,356	21,084	24,933	9,206	9,540
RAINBOW TROUT	0	0	0	0	0	0	0	0	0	1	0
BROWN TROUT	0	0	0	0	1	0	0	1	0	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0	0
TIGER MUSKY	0	0	0	0	0	0	0	0	0	0	0
CARP	2	0	0	0	0	0	0	1	0	0	0
SPOTTAIL SHINER	0	0	0	0	0	0	0	0	0	0	0
QUILLBACK	0	0	0	0	0	0	0	0	0	0	6
WHITE SUCKER	0	2	0	0	1	0	0	0	0	0	0
SHORTHEAD REDHORSE	7	23	15	147	4	4	0	15	16	9	14
YELLOW BULLHEAD	0	0	0	0	0	0	0	0	0	0	0
BROWN BULLHEAD	62	29	66	97	32	166	37	3	22	24	24
CHANNEL CATFISH	32	85	115	63	23	56	64	55	34	56	22
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0	0
WHITE PERCH	0	2	61	2,305	1,611	2,209	122	85	6	5	8
STRIPED BASS	5	4	12	8	9	2	2	1	14	6	0
STRIPED BASS HYBRID	0	0	0	0	0	0	0	0	0	0	0
ROCK BASS	0	0	0	0	1	0	0	0	0	0	0
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	0	0
BLUEGILL	0	0	0	1	0	2	0	0	0	1	0
SMALLMOUTH BASS	2	1	10	11	1	2	6	26	31	11	6
LARGEMOUTH BASS	0	0	0	0	0	0	1	0	0	0	0
YELLOW PERCH	0	0	0	0	0	5	0	0	0	0	0
WALLEYE	5	3	5	6	3	7	1	5	8	3	2
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	1	0	1	0	0	0	1	0	0	0	0
Total	22,589	25,377	17,730	19,830	28,188	24,269	12,618	21,451	25,141	10,189	10,132

Table 1 (continued)

Date	5/15	5/16	5/17	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25
Start Fishing Time	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00
End Fishing Time	18:00	17:40	18:10	18:00	17:40	17:25	18:00	17:45	17:40	18:15	18:30
Elapsed Fishing Time	10.0	9.7	10.2	10.0	9.7	9.4	10.0	9.8	9.7	10.3	10.5
Viewing Hours	10.0	10.0	10.5	10.0	10.0	10.0	10.0	10.0	10.0	10.5	11.0
Lifts Per Day	16	13	19	14	18	17	19	15	16	19	15
Water Temperature (°F)	62.5	61.6	62.6	63.6	64.2	65.2	65.3	64.9	65	66.3	69.2
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0	0
AMERICAN SHAD	273	91	440	223	500	290	525	202	76	110	109
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0	0
BLUEBACK HERRING	2	0	0	2	0	0	7	5	1	1	1
ALEWIFE	0	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	7,311	8,355	8,082	17,806	8,852	19,531	3,190	8,405	23,145	22,911	17,767
RAINBOW TROUT	0	0	1	0	0	0	1	0	0	1	2
BROWN TROUT	0	0	0	0	0	0	0	0	0	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0	1
TIGER MUSKY	0	0	0	0	0	0	0	0	0	0	0
CARP	1	0	0	0	0	0	1	0	0	0	14
SPOTTAIL SHINER	0	0	0	0	0	0	0	0	0	0	0
QUILLBACK	9	21	10	2	2	0	1	8	5	0	1
WHITE SUCKER	0	0	0	0	0	0	0	0	0	0	0
SHORTHEAD REDHORSE	6	60	29	6	6	1	37	29	9	3	2
YELLOW BULLHEAD	0	0	0	0	0	0	0	0	0	0	0
BROWN BULLHEAD	0	15	24	11	68	21	53	26	68	11	57
CHANNEL CATFISH	10	38	73	34	58	32	69	34	140	29	104
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	0	0
WHITE PERCH	0	11	17	54	17	6	6	3	2	4	1
STRIPED BASS	1	7	4	4	6	9	6	5	9	6	7
STRIPED BASS HYBRID	1	0	0	0	0	0	0	0	1	0	0
ROCK BASS	0	2	1	0	0	0	0	0	0	0	0
GREEN SUNFISH	1	0	0	0	0	0	0	0	0	0	0
BLUEGILL	0	0	5	0	0	1	1	0	3	0	0
SMALLMOUTH BASS	9	38	35	35	26	16	14	16	13	12	10
LARGEMOUTH BASS	0	0	0	0	1	0	0	0	0	0	0
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0	1
WALLEYE	3	36	31	52	11	10	46	38	22	23	26
ATLANTIC NEEDLEFISH	0	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	1	0	1	0	1	0	0	1	0	0
Total	7,627	8,675	8,752	18,230	9,547	19,918	3,957	8,771	23,495	23,111	18,103

Table 1 (continued)

Date	5/26	5/27	5/28	5/29	5/30	5/31	6/1	6/2	6/3	Season Total
Start Fishing Time	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	8:00	
End Fishing Time	18:00	17:40	18:00	17:40	17:40	17:40	18:00	18:00	17:40	
Elapsed Fishing Time	10.0	9.7	10.0	9.7	9.7	9.7	10.0	10.0	9.7	525
Viewing Hours	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	536
Lifts Per Day	15	19	14	13	12	17	15	19	11	860
Water Temperature (°F)	71.4	71.9	72.4	75.2	77.1	79.3	80.7	80.2	80.6	
AMERICAN EEL	1	0	0	3	0	3	0	4	1	17
AMERICAN SHAD	41	276	137	217	213	247	132	102	43	14,276
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0
BLUEBACK HERRING	5	0	0	0	0	0	1	0	2	34
ALEWIFE	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	23,522	22,022	7,026	7,082	2,783	10,363	2,527	1,742	3,044	833,681
RAINBOW TROUT	0	0	1	0	0	2	0	0	0	18
BROWN TROUT	0	0	0	1	0	0	0	0	0	10
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	1
TIGER MUSKY	0	0	0	0	0	0	0	0	0	1
CARP	19	18	12	5	6	379	336	5	617	1,440
SPOTTAIL SHINER	0	0	0	0	0	0	0	0	0	11
QUILLBACK	11	5	5	11	105	48	113	203	149	876
WHITE SUCKER	0	0	0	0	0	0	0	0	0	9
SHORTHEAD REDHORSE	2	5	0	5	2	0	0	0	0	1,019
YELLOW BULLHEAD	0	0	0	0	0	0	0	0	0	1
BROWN BULLHEAD	34	57	42	12	29	12	18	2	6	1,989
CHANNEL CATFISH	123	253	171	232	110	389	464	51	142	3,414
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	1
WHITE PERCH	0	2	0	0	0	0	0	0	0	6,544
STRIPED BASS	10	22	7	5	3	6	7	4	6	236
STRIPED BASS HYBRID	0	0	0	0	0	0	0	0	0	3
ROCK BASS	2	1	0	0	0	0	0	0	0	7
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	1
BLUEGILL	7	0	0	0	0	7	4	11	0	58
SMALLMOUTH BASS	9	23	9	9	11	2	4	4	0	679
LARGEMOUTH BASS	0	0	0	1	1	0	0	0	1	12
YELLOW PERCH	0	0	0	0	0	0	0	0	0	12
WALLEYE	37	83	20	16	19	34	28	37	46	750
ATLANTIC NEEDLEFISH	0	3	1	7	16	10	7	4	1	49
SEA LAMPREY	0	1	1	0	0	0	2	1	0	30
Total	23,823	22,771	7,432	7,606	3,298	11,502	3,643	2,170	4,058	865,179

*Hobo water temperature data logger placed in EFL trough.

Table 2

Summary of American shad catch, Maryland DNR recaptures, daily average river flow, water temperature, turbidity (secchi), unit operation, entrance gates utilized, attraction flow, and average project water elevations during operation of the Conowingo Dam EFL in 2016.

Date	American Shad Catch	MD DNR Recaptures	Marietta Water		Secchi (in)	Maximum Units in Operation	Entrance Gates Utilized		Attraction Flow (cfs)	Tailrace Elevation (ft)	Forebay Elevation (ft)	Crest Gates Open
			River Flow (cfs)	Temp. (°F)			Gates	Flow (cfs)				
4/1	14		25,900	56.9	23	7	A/C	310	19.5	107.0	0	
4/2	DNO		25,700	57.8								
4/3	7		25,000	56.1	20	2	A	310	17.8	106.2	0	
4/4	DNO		24,600	54.6								
4/5	2		25,300	54.1	19	7	C/A	310	18.5	107.1	0	
4/6	DNO		25,500	53.2								
4/7	3		27,000	54	19	2	A	310	18.0	107.5	0	
4/8	DNO		30,400	53.8								
4/9	0		32,400	52.8	19	5	C	310	21.7	107.3	0	
4/10	DNO		37,900	49.9								
4/11	0		52,400	50.7	20	4	C	310	21.8	107.5	0	
4/12	DNO		52,400	50.9								
4/13	0		45,900	49.8	24	4	C	310	22.4	108.3	2	
4/14	DNO		44,200	49.7								
4/15	0		54,700	52.2	30	4	C	310	23.0	108.5	2	
4/16	DNO		54,200	52.5								
4/17	2		47,000	54.9	36	7	C	310	22.0	107.0	0	
4/18	DNO		41,400	56.9								
4/19	54		37,100	58.9	36	7	C	310	22.2	108.0	0	
4/20	457		33,800	59.6	24	8	C/A	310	20.0	106.1	0	
4/21	1,487	2 Orange	31,100	61.3	28	8	C/A	310	18.5	107.0	0	
4/22	91		29,000	63.1	30	8	C/A	310	19.5	107.0	0	
4/23	799	3 Orange	27,700	64.5	30	7	A/C	310	20.1	107.2	0	
4/24	188		26,500	64.1	30	6	A/C	310	20.5	107.3	0	
4/25	26		25,300	65.4	30	7	A/C	310	20.2	107.1	0	
4/26	682	3 Orange	24,000	66.6	30	6	A/C	310	18.4	106.6	0	
4/27	155		23,000	67.1	29	6	A/C	310	18.5	107.7	0	
4/28	1,042	3 Orange	22,400	66.4	30	6	A/C	310	19.6	107.3	0	
4/29	218	1 Blue	22,600	64.9	36	7	A/C	310	19.6	107.7	0	
4/30	213	1 Orange	22,000	64.1	36	2	A	310	18.7	107	0	
5/1	1,398	6 Orange	22,100	63.7	30	6	A/C	310	19.0	107.7	0	
5/2	753	3 Orange	23,400	64	30	6	C/A	310	20.1	107.2	0	
5/3	209		29,400	64.7	36	6	C/A/C	310	21.1	108.7	0	
5/4	132		36,000	63.2	36	9	C/A/C	310	21.1	107.8	0	
5/5	22		49,600	60.3	25	11	C	310	23.5	108	0	
5/6	8		53,100	59.1	21	11	C	310	23.2	108.2	0	
5/7	159		55,800	59.5	21	10	C/A/C	310	21.5	107.5	0	

Table 2
Continued.

Date	American Shad Catch	MD DNR Recaptures*	Marietta Water		Secchi (in)	Maximum Entrance		Tailrace Elevation (ft)	Forebay Elevation (ft)	Crest Gates Open
			River Flow (cfs)	Temp. (°F)		Units in Operation	Utilized Flow (cfs)			
5/8	46		53,300	59.4	13	10	C	21.5	108.0	0
5/9	210		50,700	59.4	22	10	C/A/C	21.1	107.5	0
5/10	28		47,500	59.4	24	10	C	22.2	107.7	0
5/11	172		42,600	60	21	10	C	22.9	107.5	0
5/12	77		38,200	61.4	18	9	C	22.3	107.2	0
5/13	867	3 Orange/1 Blue	35,000	62	23	9	C/A/C	21.3	107.6	0
5/14	508		33,000	62.7	24	7	C/A/C	18.0	107.1	0
5/15	273	1 Orange	31,900	62.5	30	6	A/C	20.0	108.0	0
5/16	91	1 Orange	31,600	61.6	26	8	C/A	20.5	107.2	0
5/17	440	1 Orange	31,500	62.6	19	8	C/A/C	21.0	107.6	0
5/18	223	2 Orange	31,000	63.6	24	8	C/A/C	21.1	107.7	0
5/19	500	1 Orange	29,600	64.2	22	9	C/A/C	20.7	107.2	0
5/20	290		27,400	65.2	24	7	C/A/C	20.5	107.5	0
5/21	525		25,800	65.3	21	5	C/A	19.0	107.0	0
5/22	202		25,600	64.9	24	5	C/A	18.2	107.7	0
5/23	76		25,600	65	28	7	C	22.0	106.8	0
5/24	110		30,100	66.3	28	7	C	21.1	107.0	0
5/25	109	1 Orange	33,500	69.2	30	7	A/C	21.3	107.2	0
5/26	41		32,500	71.4	28	8	C	22.0	107.5	0
5/27	276	1 Orange/1 Blue	29,600	71.9	30	9	C	21.1	107.6	0
5/28	137	1 Orange	27,100	72.4	27	6	C	21.0	107.9	0
5/29	217	1 Orange	25,000	75.2	28	6	A/C	19.3	107.8	0
5/30	213	1 Orange	23,700	77.1	30	6	A/C	19.5	107.8	0
5/31	247	1 Orange	23,000	79.3	30	8	A/C	20.2	107.2	0
6/1	132	1 Orange	20,800	80.7	30	7	A/C	20.2	107.5	0
6/2	102	2 Orange	19,000	80.2	32	6	A	18.3	106.9	0
6/3	43		17,900	80.6	30	6	A/C	19.1	106.7	0

DNO = Did Not Operate

Orange (39) = 2016 MDNR floy tags

Blue (3) = 2015 MDNR floy tags

Table 3

Hourly summary of American shad passage at the Conowingo Dam East Fish Passage Facility in 2016.

	Date:	4/1	4/2	4/3	4/4	4/5	4/6	4/7	4/8	4/9	4/10	4/11	4/12
Observation Time-Start:		9:00		10:00	9:00	9:45	8:00	8:15	8:15	8:15	8:00	8:00	8:15
Observation Time-End:		16:50		16:50	16:50	16:50	16:15	16:15	14:15	15:45	16:30	16:00	16:20
Military Time (hrs)													
0600 to 0659													
0700 to 0759													
0800 to 0859													
0900 to 0959		0				0		0		0		0	
1000 to 1059		2		0		0		0		0		0	
1100 to 1159		2		0		0		0		0		0	
1200 to 1259		1		0		1		0		0		0	
1300 to 1359		2		3		0		0		0		0	
1400 to 1459		3		1		0		2		0		0	
1500 to 1559		3		0		0		0		0		0	
1600 to 1659		1		3		1		1					
1700 to 1759													
1800 to 1859													
1900 to 1959													
2000 to 2059													
Total		14	0	7	0	2	0	3	0	0	0	0	0

	Date:	4/13	4/14	4/15	4/16	4/17	4/18	4/19	4/20	4/21	4/22	4/23	4/24
Observation Time-Start:		8:15	8:10	8:00	8:10	8:00	8:15	8:00	8:00	8:15	8:00	8:00	8:00
Observation Time-End:		15:45	16:20	16:00	18:20	16:00	18:15	16:00	18:00	18:20	18:00	18:00	18:00
Military Time (hrs)													
0600 to 0659													
0700 to 0759													
0800 to 0859		0		0		0		0	7	11	21	6	25
0900 to 0959		0		0		0		0	0	19	3	9	32
1000 to 1059		0		0		1		0	2	25	0	9	6
1100 to 1159		0		0		0		6	2	29	0	20	8
1200 to 1259		0		0		0		4	0	92	4	66	10
1300 to 1359		0		0		0		6	7	157	6	42	3
1400 to 1459		0		0		0		11	57	342	10	101	30
1500 to 1559		0		0		1		27	112	468	5	201	27
1600 to 1659									164	246	13	269	30
1700 to 1759									106	75	29	76	17
1800 to 1859													
1900 to 1959													
2000 to 2059													
Total		0	0	0	0	2	0	54	457	1,487	91	799	188

**Table 4
Summary Information for Conowingo EFL Volitional Passage, 1997 through 2016.**

Year	#Days of Ops	#Hrs of Ops	Total # of Lifts	# Fish passed	# Am. shad	# Gizzard shad	# Herring	Avg.#fish/lift	Ratio A.S./Gizz
1997	64	640	652	719,297	90,971	344,332	242,815	1,103	1/4
1998	50	433	460	712,993	39,904	654,575	706	1,550	1/16
1999	52	467	610	1,184,101	69,712	950,500	130,639	1,941	1/14
2000	45	368	570	493,955	153,546	317,753	14,965	866	1/2
2001	43	360	559	921,916	193,574	429,461	292,379	1,649	1/2
2002	49	440	560	656,894	108,001	513,794	2,111	1,173	1/5
2003	44	416	645	589,177	125,135	459,634	551	913	1/4
2004	44	390	590	715,664	109,360	602,677	190	1,212	1/6
2005	52	434	541	377,762	68,926	305,378	4	698	1/4
2006	61	430	619	714,918	56,899	655,990	0	1,154	1/12
2007	39	335	479	539,203	25,464	508,627	889	1,125	1/20
2008	51	409	483	943,838	19,914	919,975	5	1,954	1/46
2009	57	495	618	915,417	29,272	876,412	231	1,481	1/30
2010	59	526	685	857,263	37,757	813,429	5	1,251	1/22
2011	15	142	259	289,453	20,571	257,522	19	1,117	1/13
2012	62	633	1,230	1,109,911	22,143	1,070,672	52	902	1/48
2013	60	575.6	925	1,094,526	12,733	1,076,048	7	1,183	1/85
2014	54	509	988	1,192,750	10,425	1,170,200	136	1,207	1/112
2015	46	433	674	754,057	8,341	742,661	13	1,119	1/89
2016	55	536	860	865,179	14,276	833,681	34	1,006	1/58

Table 5

Summary of selected operation and fish catch statistics at the Conowingo Dam East Fish Passage Facility, 1991 to 2016.

Year	Number of		Operating Time (hrs)	Number of Species	American shad	Blueback herring	Alewife	Hickory shad
	Days Operated	Lifts						
1991	60	1168	647.2	42	13,897	13,149	323	0
1992	49	599	454.1	35	26,040	261	3	0
1993	42	848	463.5	29	8,203	4,574	0	0
1994	55	955	574.8	36	26,715	248	5	1
1995	68	986	706.2	36	46,062	4,004	170	1
1996	49	599	454.1	35	26,040	261	3	0
1997	64	652	640.0	36	90,971	242,815	63	0
1998	50	652	640.0	33	39,904	700	6	0
1999	52	610	467.0	31	69,712	130,625	14	0
2000	45	570	367.8	30	153,546	14,963	2	0
2001	43	559	359.8	30	193,574	284,921	7,458	0
2002	49	560	440.7	31	108,001	2,037	74	6
2003	44	645	416.6	25	125,135	530	21	0
2004	44	590	390.3	30	109,360	101	89	0
2005	52	541	434.3	30	68,926	4	0	0
2006	61	619	429.8	32	56,899	0	0	4
2007	39	479	335.3	31	25,464	460	429	0
2008	51	483	407.0	29	19,914	1	4	0
2009	57	618	495.6	30	29,272	71	160	0
2010	59	685	526.2	38	37,757	4	1	0
2011	15	259	142.4	24	20,571	17	2	20
2012	62	1230	633.7	35	22,143	25	27	0
2013	60	925	575.6	27	12,733	7	0	1
2014	54	988	509	34	10,425	25	111	2
2015	46	674	433	28	8,341	3	10	8
2016	55	860	536	27	14,276	34	0	0

Table 6

Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2016.

	Conowingo		Holtwood		Safe Harbor		York Haven	
	East	Number	% of C.E.L.	Number	% of Holt.	Number	% of S.H.	
1997	90,971	28,063	30.8%	20,828	74.2%	-	-	
1998	39,904	8,235	20.6%	6,054	73.5%	-	-	
1999	69,712	34,702	49.8%	34,150	98.4%	-	-	
2000	153,546	29,421	19.2%	21,079	71.6%	4,687	22.2%	
2001	193,574	109,976	56.8%	89,816	81.7%	16,200	18.0%	
2002	108,001	17,522	16.2%	11,705	66.8%	1,555	13.3%	
2003	125,135	25,254	20.2%	16,646	65.9%	2,536	15.2%	
2004	109,360	3,428	3.1%	2,109	61.5%	219	10.4%	
2005	68,926	34,189	49.6%	25,425	74.4%	1,772	7.0%	
2006	56,899	35,968	63.2%	24,929	69.3%	1,913	7.7%	
2007	25,464	10,338	40.6%	7,215	69.8%	192	2.7%	
2008	19,914	2,795	14.0%	1,252	44.8%	21	1.7%	
2009	29,272	10,896	37.2%	7,994	73.4%	402	5.0%	
2010	37,757	16,472	43.6%	12,706	77.1%	907	7.1%	
2011	20,571	21	0.1%	8	38.1%	0	0.0%	
2012	22,143	4,238	19.1%	3,089	72.9%	224	7.3%	
2013	12,733	2,503	19.7%	1,927	77.0%	202	10.5%	
2014	10,425	2,589	24.8%	1,336	51.6%	8	0.6%	
2015	8,341	5,286	63.3%	3,896	73.7%	43	1.1%	
2016	14,276	6,718	47.0%	4,242	63.1%	178	4.2%	

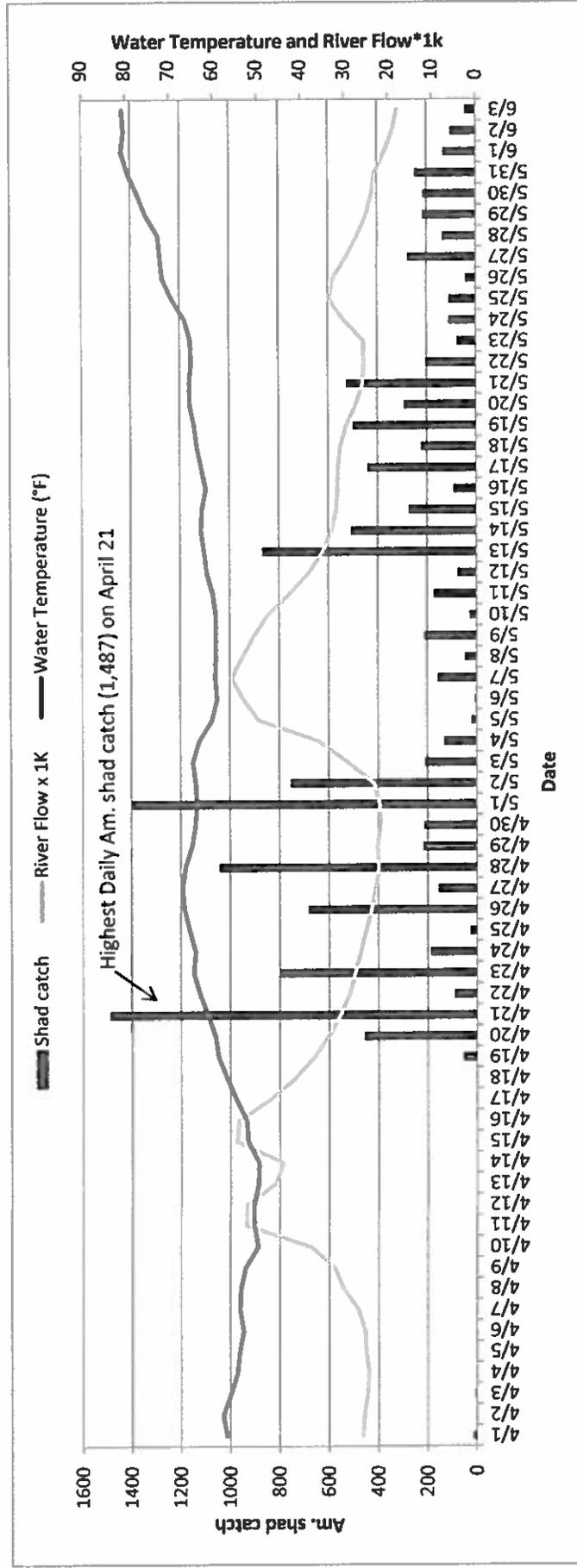


Figure 1

A plot of river flow (x 1000 cfs) (USGS Marietta Gauge) and water temperature (°F) in relation to daily American shad passage at the Conowingo EFL, spring 2016.

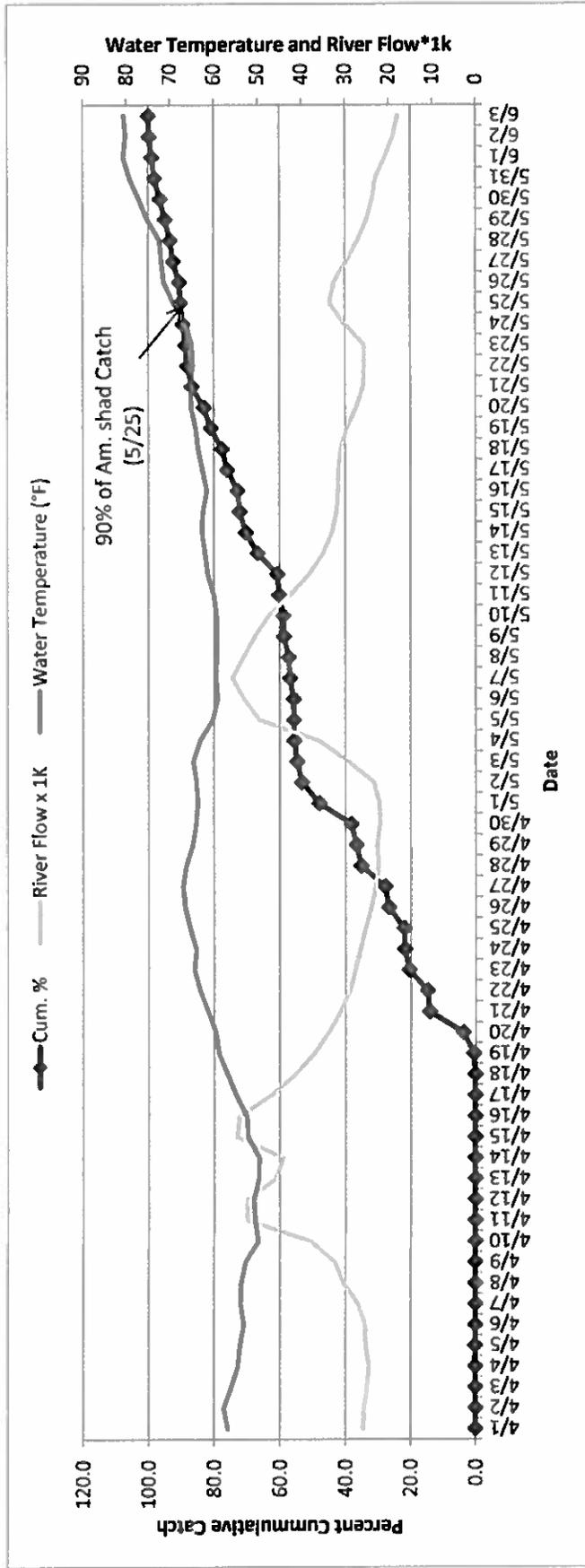


Figure 2

A plot of river flow (x 1000 cfs) (USGS Marietta Gauge) and water temperature (°F) in relation to the percent cumulative American shad passage at the Conowingo EFL, spring, 2016.