

Summary of Operations at the Safe Harbor Fish Passage Facility Spring 2018

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Executive Summary

Operation of the Safe Harbor Fish Lift began 26 April, 2018; 4 days prior to Holtwood passing its first American Shad into Lake Aldred. The average water temperature on 26 April was 54°F and the river flow was 56,400 cfs. The first American Shad was passed at Safe Harbor on 3 May. Daily fish lift operations were conducted from 30 April through 14 May, with operations suspended from 15 May through 25 May due to high river flows. Daily operations resumed on 26 May and continued through season end on 8 June. Operation at the Safe Harbor Fish Lift ended on 8 June due to the dwindling fish catch and water temperatures at or above 70° F; indications that the migration run was ending. Due to high river flow, the Safe Harbor fish lift was operated on 15 fewer days in 2018 compared to 2017. The 2018 fish passage season marks the twenty-second season of volitional fish passage at the Safe Harbor Fish Lift.

The Safe Harbor Fish Lift passed 120,465 fish of 16 species and 1 hybrid upstream into Lake Clarke. Gizzard shad (113,849), smallmouth bass (1,894), and channel catfish (1,751), dominated the catch, and comprised 97.5% of the total fish collected and passed. Gizzard shad was the dominant species passed and comprised 94.5% of the catch.

A total of 661 American Shad was passed during the 2018 season at Safe Harbor comprising 31 days of operation. The highest daily passage of American Shad occurred on 8 May, when 125 American Shad were captured and passed upstream. The passage of American Shad during the entire season was generally low during all hours of operation, with the highest hour of passage occurring from 1500 hours to 1559 hours (98). The 4-hour period between 1200 and 1559 hours accounted for 49% of the total season passage.

Fishway operations were conducted at water temperatures ranging from 54.0°F to 75.7°F and river flows of 29,200 to 95,400 cfs. River flows were generally higher during the entire 2018 fish passage season, resulting in the suspension of fish passage operations from 15 through 25 May due to river flows exceeding 100,000 cfs. Water temperature was generally at or above 70° F from 27 May through season end on 8 June.

On 17 of the 31 days of operation, water clarity was good (18-24 inches of visibility at the viewing window), allowing the viewing technicians to accurately identify American Shad and other fish species. Although viewing conditions were adequate in 2018, no American Shad with Maryland DNR floy tags were observed at the Safe Harbor Fishway.

Prior to the start of Safe Harbor fish lift operations in 2016, federal and state resource agency personnel stated their concern regarding the station's use of an air bubbler system to keep the fish trough exit clear of debris during fish passage operation. The resource agencies requested that the station evaluate fish passage when the air bubbler system was in use to determine if the bubbler system impedes fish movement through the fish trough. Safe Harbor indicated to FERC and the resource agencies that fish lift personnel would document deviations in fish behavior/passage if and when the air bubbler system was utilized.

During the 2016, 2017, and 2018 fish passage seasons, daily observations of fish behavior/passage were made by the fish counting technicians. At no time during fish passage operations did the technicians observe fish "stacking up" at the trough exit area or large numbers of fish swimming downstream past the window after having passed the viewing window earlier in the day.

Future operations of the Safe Harbor Fish Lift will build on the past twenty-two years of experience.

1.0 Introduction

On June 1, 1993 representatives of Safe Harbor Water Power Corporation (SHWPC), two other upstream utilities, various state and federal resource agencies, and two sportsmen clubs signed the 1993 Susquehanna River Fish Passage Settlement Agreement. The agreement committed Safe Harbor, Holtwood, and York Haven Hydroelectric projects to provide migratory fish passage at the three locations by spring 2000. A major element of this agreement was for SHWPC, the operator of the Safe Harbor Hydroelectric Project (Safe Harbor), to construct and place in operation an upstream fishway by April 1, 1997. The fishway that provides fish access into Lake Clarke was placed into service in April of 1997. Brookfield Renewable is now the sole owner/operator of the Safe Harbor Hydroelectric Station.

Objectives for 2018 operation were to (1) monitor passage of migratory and resident fishes through the fishway; (2) assess fishway effectiveness; and (3) continue to assess any impacts of fish passage through the trough when the air bubbler system is in use during fish passage operations.

2.0 Safe Harbor Operation

2.1 Project Operation

Safe Harbor is situated on the Susquehanna River (river mile 31) in Lancaster and York counties, Pennsylvania. The project consists of a concrete gravity dam 4,869 ft long and 75 ft high, a powerhouse 1,011 ft long with 12 generating units with a combined generating capacity of 417.5 MW, and a reservoir of 7,360 surface acres. The net operating head is about 55 ft.

Safe Harbor is the third upstream dam on the Susquehanna River. The station was built in 1931 and originally consisted of seven generating units. Five units were added and operational in 1986, which increased the hydraulic capacity to 110,000 cfs. Each unit is capable of passing approximately 8,500 cfs. Natural river flows in excess of 110,000 cfs are spilled through three regulating and 28 crest gates. The five new mixed-flow turbines have seven fixed-runner blades, a diameter of 240 in, and runner speed of 76.6 rpm. The runner blades are somewhat spiraled and do not have bands at the top or bottom. Two of these new turbines are equipped with aeration systems that permit a unit to draw air into the unit (vented mode) or operate conventionally (unvented mode). The seven old units are five-blade Kaplan type turbines. These units have horizontal, adjustable, propeller-shaped blades.

2.2 Fishway Design and Operation

2.2.1 Fishway Design

The fishway was sized to pass a design population of 2.5 million American Shad and 5 million river herring. The design incorporated numerous criteria established by the USFWS and the resource agencies. Physical design parameters for the fishway are given in the 1997 summary report (Normandeau Associates, Inc. 1998).

The Safe Harbor fish lift has three entrances (gates A, B, and C). The lift has a fish handling system, which includes a mechanically operated crowder, picket screen, hopper, and hopper trough gate. Fishes captured in the lift are sluiced into the trough and pass into Lake Clarke. Attraction flow, in, through, and from the lift is supplied through a piping system controlled by motor operated valves, attraction water gates, attraction water pools, and two diffusers that are gravity fed from two

intakes. Generally, water conveyance and attraction flow is controlled by regulating two motor operated valves and three attraction water gates, which control flow from and into the attraction water pools and the three entrance gates. Fish that enter the fishway entrances are attracted by water flow into the mechanically operated crowder chamber by regulating gate F. Once inside, fish are crowded over the hopper (capacity = 4,725 gallons), lifted, and sluiced into the trough. Fish swim upstream past a counting facility, which includes a separate public viewing room and into the forebay approximately 150 ft upstream of the dam. The trough extends 40 ft into the forebay in order to sluice the fish past the skimmer wall.

Conceptual design guidelines for fishway operation included several entrance combinations. They are (1) entrance A, B, and C; (2) entrance B and C; (3) entrance A and C, and (4) entrance A, B, and C individually. Operation during the 2018 season utilized a combination of entrances A and C.

2.2.2 Fishway Operation

Safe Harbor fishway operation generally commences soon after passage of approximately 500 American Shad via the Holtwood fishway. However, in 2018, operations commenced on 26 April, 4 days prior to Holtwood passing its first American Shad into Lake Aldred. Operations commenced earlier than required to accommodate an inspection tour of the fish lift facility by the Resource Agencies.

The Safe Harbor fishway began operation on 26 April, with operations ending on 8 June. Lift operations ended due to the dwindling fish catch and rising water temperatures; indications that the adult American Shad migration season was ending.

Throughout the 2018 season, operation of the Safe Harbor fishway was based on methods established during previous spring migration seasons. A detailed description of the fishway's major components and their operation is found in the 1997 and 1998 summary reports (Normandeau Associates, Inc. 1998, 1999).

Daily operation of the Safe Harbor fishway was dependent on the American Shad catch and managed in a flexible fashion. To minimize interruptions to fishway operation, Safe Harbor performed maintenance activities that included periodic cleaning of the exit channel, daily inspections, cleaning of picket screens, and other routine maintenance activities. During operation on 26 April, the crowder malfunctioned and was out of service for the remainder of the season. The failure was a limit switch that was damaged when it was submerged during a high flow event. Parts to complete the repair are onsite and ready for installation. The crowder will be repaired prior to the start of the 2019 fish passage season. Due to river flows at or above 100,000 cfs, fish lift operations were suspended from 15 through 25 May which may have impacted the passage of American Shad at Safe Harbor this season. Aside from the issues stated previously, no other issues occurred during the fish passage season.

2.3 Fish Counts

Fish lifted and sluiced into the trough were identified to species and enumerated as they passed the counting window by a biological technician. As fish swim upstream and approach the counting area they are directed by a series of fixed screens to swim up and through a 3 ft wide channel on the east side of the trough. The channel is adjacent to a 4 ft by 10 ft window located in the counting room where fish are enumerated prior to exiting the fishway. Fish passage was controlled by the biological technician, who opened/closed a gate located downstream of the viewing window from a controller mounted inside the counting room. Each night, after operations ended for the day, fish were denied passage from the fishway by closing the gate downstream of the window.

A 1,500 watt halogen lamp mounted above the viewing window and three adjustable 500 watt underwater lights (two at mid-depth on either side of the window and one on the bottom) gave the biologist and/or technician a degree of control over lighting conditions at the window. Overhead and underwater light intensity was adjusted daily, based on the constantly changing ambient light conditions. In addition, a screen capable of adjusting the channel width at the counting window from 18 in to 36 in (and a range of intermediate widths) was adjusted as viewing conditions and fish passage dictated. For the entire 2018 season, the adjustable screen was set at 18 in.

At the end of each hour, fish passage data were recorded on a worksheet and entered into a Microsoft Excel spreadsheet 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 e-mailed to plant personnel. Each day's data were backed up on electronic media and stored off site. Daily reports and weekly summaries of fish passage were electronically distributed to members of the SHFPTAC and other cooperators.

3.0 Results

3.1 Relative Abundance

The relative abundance of fishes collected and passed in 2018 by the Safe Harbor fishway is presented in Table 1. A total of 120,465 fish of 16 species and 1 hybrid passed upstream into Lake Clarke. Gizzard shad (113,849) was the dominant species passed and comprised 94.5% of the catch. Some 661 American Shad were passed upstream through the fishway and comprised < 1% of the catch. Other predominant fishes passed included smallmouth bass (1,894), channel catfish (1,751), and shorthead redhorse (998). The highest fish passage day occurred on 13 May, when 12,633 fish, (98.6% gizzard shad), were passed.

3.2 American Shad Passage

The Safe Harbor fishway passed 661 American Shad in 2018 during 31 days of operation (Tables 1 and 2). This year's passage of American Shad (661) is the second lowest number of American Shad passed since 1997 (Table 3). Safe Harbor managed to pass 45.3% of the American Shad passed at Holtwood Dam and 9.4% of the American Shad passed by Conowingo Dam, (Table 3). Peak shad passage occurred on 8 May, when 125 American Shad were captured and passed during 9 hours of viewing operation. American Shad passage from 5 through 14 May, (651), accounted for all but 10 of the American Shad passed at Safe Harbor in 2018.

American Shad were passed at water temperatures of 60.2°F to 75.7°F and river flows of 29,200 to 65,400 cfs (Table 2 and Figures 1 and 2). River flows were higher than observed in 2016 and 2017, with a major high flow event (river flow > 100,000 cfs) occurring between 15 and 25 May resulting in spillage and suspension of fish passage operations. Water temperature did not spike drastically in 2018 compared to other recent years with temperatures $\geq 70^\circ$ F recorded from 28 May to season end on 8 June.

The number of American Shad observed passing through the trough by hour is shown in Table 4. With the season's shad catch broken down based on hours of observation, passage rates were generally low throughout the entire day. The highest passage period for American Shad during the entire season was observed between 1300 hrs to 1559 hrs (253), accounting for 38% of the total season passage. The highest number of American Shad passed in one hour (25) occurred between 1300 hrs and 1359 hrs on 8 May.

During the 2018 season, the Safe Harbor fishway did not pass any American Shad with MD DNR floy tags that had been passed by downstream fish lift facilities.

3.3 Other Alosids

Passage of other alosids, (alewife, blueback herring, and hickory shad), at the Safe Harbor fishway was not observed in 2018.

3.4 Evaluation of Air Bubbler System

Prior to the start of Safe Harbor fish lift operations in 2016, federal and state resource agency personnel stated their concern regarding the station's use of an air bubbler system to keep the fish trough exit clear of debris during fish passage operation. The resource agencies requested that the station evaluate fish passage when the air bubbler system is in use to determine if the bubbler system impedes fish movement through the fish trough. Safe Harbor indicated to FERC and the resource agencies that fish lift personnel would document deviations in fish behavior/passage if and when the air bubbler system was utilized.

During the 2018 fish passage season, daily observations of fish behavior/passage were made by the fish counting technicians whether the air bubbler system was on or off. At no time during fish passage operations did the technicians observe fish "stacking up" at the trough exit area or large numbers of fish swimming downstream past the window after having passed the viewing window earlier in the day.

Since 1997 (initial year of operation at Safe Harbor), fish counting technicians have observed on a limited basis an initial unwillingness of fish to quickly swim past the viewing window. Upon inspection of the facility by station personnel, the cause has been a build-up of debris on the retractable screens at the viewing windows. Once the screens are cleaned of debris, fish passage returns to normal. It appears, based on these observations, that the air bubbler system located at the fish trough exit does prevent large amounts of debris from entering the fish trough when present at the trough exit, thus aiding in the maintenance of normal fish passage conditions for all fish species that enter and pass through the Safe Harbor fish lift.

4.0 Summary

Aside from the crowder issue stated previously in Section 2.2.2, the 2018 Safe Harbor fishway operating season was conducted with minimal disruptions to operations due to mechanical problems.

A total of 661 American Shad were passed into Lake Clarke, or 45.3% of the American Shad that were passed into Lake Aldred by the Holtwood fishway (Table 3), similar to the passage percentage observed in 2008 (44.81%). All except 8 of the total American Shad passed at Safe Harbor occurred prior to 15 May (Figure 2), possibly due to the high river flow event that occurred from 15 through 25 May which appears to have significantly impacted American Shad passage at all of the fish passage facilities on the lower Susquehanna River in 2018. Future operations of the fishway will build on the past twenty-two years of experience.

5.0 Recommendations

- 1) Operate the fishway at Safe Harbor Dam per annual guideline developed and approved by the SHFPTAC. Fishway operation should adhere to the guideline; however, flexibility must remain with operating personnel to maximize fishway operation and performance.

6.0 Literature Cited

Normandeau Associates, Inc. 1998. Summary of operation at the Safe Harbor Fish Passage Facility in 1997. Prepared for Safe Harbor Water Power Corporation, Conestoga, PA.

Normandeau Associates, Inc. 1999. Summary of operation at the Safe Harbor Fish Passage Facility in 1998. Prepared for Safe Harbor Water Power Corporation, Conestoga, PA.

Figures

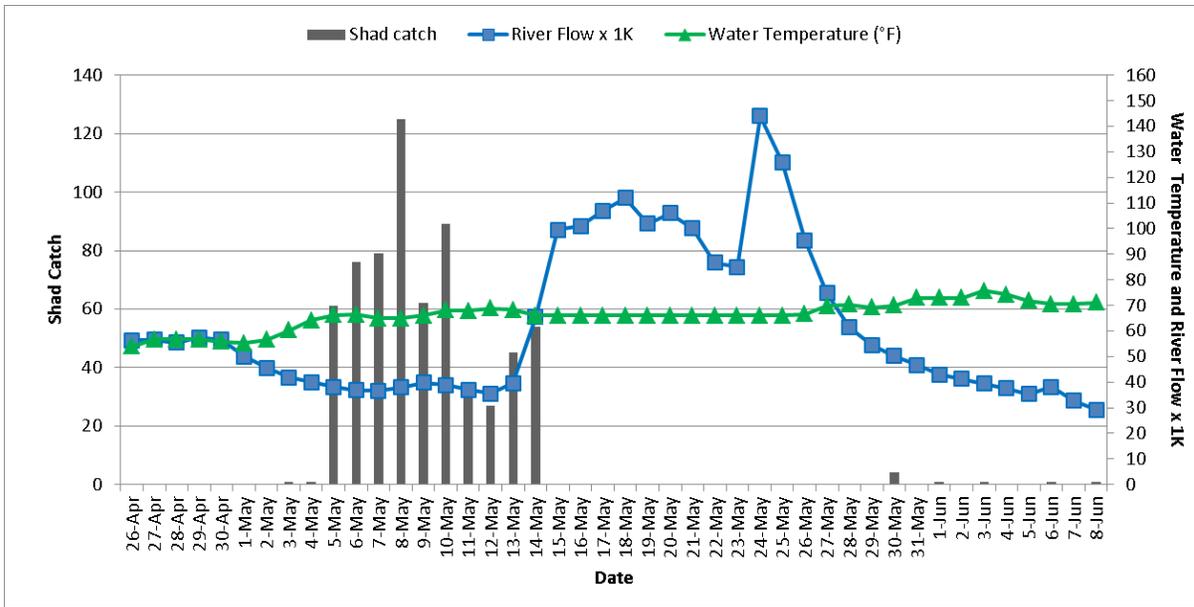


Figure 1. A plot of river flow (USGS Marietta Gauge) and water temperature (°F), in relation to the daily American Shad catch at the Safe Harbor Fish Passage Facility, Spring 2018.

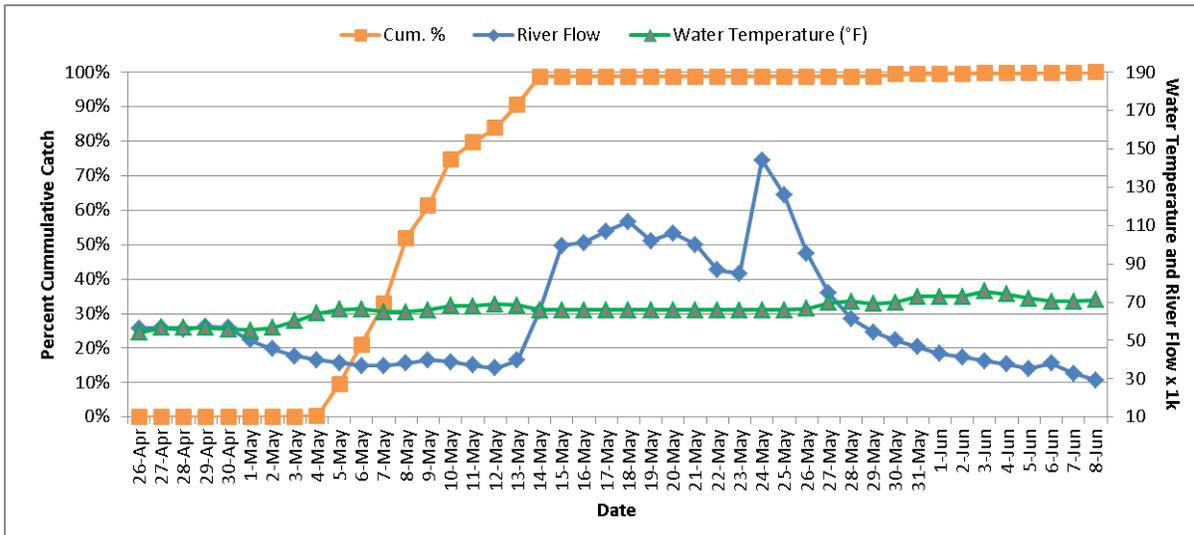


Figure 2. A plot of river flow (USGS Marietta Gauge) and water temperature (°F), in relation to the percent cumulative American Shad catch at the Safe Harbor Fish Passage Facility, Spring 2018.

Tables

Table 1. Number and disposition of fish passed daily by the Safe Harbor fishway in 2018. No operation 4/28 and 4/29 (no shad passed at Holtwood); no operation 5/15–5/25 due to high river flows.

Date	4/26	4/27	4/28	4/29	4/30	5/1	5/2	5/3	5/4	5/5	
Start Viewing Time	7:30	8:00			8:00	7:40	8:00	8:00	8:00	7:45	
End Viewing Time	17:25	17:00	Did	Did	14:10	17:40	16:50	17:30	17:00	17:30	
Elapsed Viewing Time	9.9	9.0	Not	Not	6.2	10.0	8.8	9.5	9.0	9.8	
Lifts Per Day	10	10	Operate	Operate	5	13	10	10	9	13	
Water Temperature (F)	54	56.7			55.8	55.3	56.6	60.2	64.2	66.2	
American Shad	0	0			0	0	0	1	1	61	
Gizzard Shad	42	7			137	680	273	674	2,395	6,772	
Sea Lamprey	0	0			0	0	0	0	0	0	
Muskellunge	2	0			0	0	1	0	0	0	
Tiger Musky	0	0			0	1	0	0	0	0	
Carp	0	0			0	0	0	7	13	20	
Quillback	13	1			1	1	28	71	134	132	
S. Redhorse	127	32			1	4	125	276	160	129	
Channel Catfish	0	1			0	0	0	0	14	47	
Flathead Catfish	0	0			0	0	0	0	0	0	
Rock Bass	0	2			0	0	1	0	5	0	
Bluegill	0	0			0	0	0	0	0	0	
Smallmouth Bass	62	28			0	28	47	249	406	535	
Largemouth Bass	1	0			0	0	0	2	0	2	
White Crappie	0	0			0	0	0	0	0	0	
Yellow Perch	0	2			0	0	0	0	0	0	
Walleye	4	3			0	0	0	0	14	26	
TOTALS	251	76	0	0	139	714	475	1,280	3,142	7,724	

Date	5/6	5/7	5/8	5/9	5/10	5/11	5/12	5/13	5/14	5/15	
Start Viewing Time	7:30	8:00	7:30	8:00	7:20	8:00	7:20	8:00	7:30		
End Viewing Time	16:25	16:50	16:30	16:40	17:40	17:35	17:25	17:30	16:55	Did	
Elapsed Viewing Time	8.9	8.8	9.0	8.7	10.3	9.6	10.1	9.5	9.4	Not	
Lifts Per Day	11	10	13	12	16	18	16	19	15	Operate	
Water Temperature (F)	66.4	65	65	66	68.1	67.9	68.8	68.3	66		
American Shad	76	79	125	62	89	33	27	45	54		
Gizzard Shad	8,635	9,963	9,695	3,588	2,879	3,867	4,713	12,459	8,198		
Sea Lamprey	0	0	1	0	0	0	0	0	0		
Muskellunge	0	1	1	0	0	0	0	0	0		
Tiger Musky	0	0	0	0	0	0	0	0	0		
Carp	4	5	13	14	14	35	9	3	5		
Quillback	65	8	11	20	57	34	33	1	1		
S. Redhorse	32	10	12	23	19	24	15	3	3		
Channel Catfish	92	13	29	17	97	89	86	84	78		
Flathead Catfish	0	0	0	0	0	0	0	0	0		
Rock Bass	1	0	0	2	1	0	1	0	0		
Bluegill	2	0	0	1	2	0	1	0	0		
Smallmouth Bass	169	47	99	59	52	20	27	26	5		
Largemouth Bass	1	0	0	0	0	0	0	0	0		
White Crappie	0	0	0	0	0	0	1	0	0		
Yellow Perch	0	0	0	0	0	0	0	0	0		
Walleye	9	3	2	0	6	5	4	12	3		
TOTALS	9,086	10,129	9,988	3,786	3,216	4,107	4,917	12,633	8,347	0	

Table 1. (Continued)

Date	5/16	5/17	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25
Start Viewing Time										
End Viewing Time	Did									
Elapsed Viewing Time	Not									
Lifts Per Day	Operate									
Water Temperature (F)										
American Shad										
Gizzard Shad										
Sea Lamprey										
Muskellunge										
Tiger Musky										
Carp										
Quillback										
S. Redhorse										
Channel Catfish										
Flathead Catfish										
Rock Bass										
Bluegill										
Smallmouth Bass										
Largemouth Bass										
White Crappie										
Yellow Perch										
Walleye										
TOTALS	0									

Date	5/26	5/27	5/28	5/29	5/30	5/31	6/1	6/2	6/3	6/4	6/5
Start Viewing Time	8:00	8:30	7:30	8:00	8:00	8:00	8:00	8:00	7:40	8:00	8:00
End Viewing Time	16:25	16:00	15:45	16:15	16:20	16:30	16:15	16:15	17:00	17:00	17:00
Elapsed Viewing Time	8.4	7.5	8.3	8.3	8.3	8.5	8.3	8.3	9.3	9.0	9.0
Lifts Per Day	9	11	9	9	9	9	10	9	12	12	13
Water Temperature (F)	66.6	69.7	70.4	69.2	70	73	73	73	75.7	74.2	71.8
American Shad	0	0	0	0	4	0	1	0	1	0	0
Gizzard Shad	568	3,155	2,489	5,674	1,645	2,553	2,486	6,292	7,535	4,562	960
Sea Lamprey	0	0	0	0	0	0	0	0	0	0	0
Muskellunge	0	0	0	0	0	0	0	1	0	0	0
Tiger Musky	0	0	0	0	0	0	0	0	0	0	0
Carp	2	22	1	15	62	35	5	56	32	4	1
Quillback	0	18	3	14	23	12	8	54	10	3	0
S. Redhorse	0	1	0	0	0	0	0	0	2	0	0
Channel Catfish	10	19	60	75	142	113	86	96	341	48	25
Flathead Catfish	0	0	0	1	0	0	2	0	1	0	0
Rock Bass	0	0	0	0	0	0	0	0	0	0	0
Bluegill	0	0	0	2	0	1	0	0	1	2	2
Smallmouth Bass	0	6	0	6	3	8	2	2	3	0	2
Largemouth Bass	1	0	0	0	0	0	0	0	0	0	0
White Crappie	0	0	0	0	0	0	0	0	0	0	0
Yellow Perch	0	0	0	0	0	0	0	0	0	0	0
Walleye	0	0	1	3	2	0	1	2	3	0	0
TOTALS	581	3,221	2,554	5,790	1,881	2,722	2,591	6,503	7,929	4,619	990

Table 1. (Continued)

Date	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	Season Total
Start Viewing Time	8:00	8:00	8:00								
End Viewing Time	16:50	16:15	15:50								
Elapsed Viewing Time	8.8	8.3	7.8								274
Lifts Per Day	10	9	9								350
Water Temperature (F)	70.5	70.5	71.1								
American Shad	1	0	1								661
Gizzard Shad	532	284	137								113,849
Sea Lamprey	0	0	0								1
Muskellunge	0	0	0								6
Tiger Musky	0	0	0								1
Carp	0	11	11								399
Quillback	0	1	3								760
S. Redhorse	0	0	0								998
Channel Catfish	17	5	67								1,751
Flathead Catfish	0	0	0								4
Rock Bass	0	0	0								13
Bluegill	0	0	0								14
Smallmouth Bass	1	1	1								1,894
Largemouth Bass	0	0	1								8
White Crappie	0	0	0								1
Yellow Perch	0	0	0								2
Walleye	0	0	0								103
TOTALS	551	302	221	0	120,465						

Table 2. Summary of daily average river flow as measured at USGS Gauge Marietta, water temperature, turbidity (secchi), unit operation, entrance gates utilized, attraction flow, and project water elevations during operation of the Safe Harbor fish passage facility in 2018.

Date	River Flow ¹ (mcfs)	Water Temp (°F)	Secchi (in)	Maximum # of Units Operating	Entrance Gates Utilized	Attraction Flow (cfs)	Tailrace Elevation (ft)	Forebay Elevation (ft)	Daily No. of Am. Shad Passed
26-Apr	56,400	54	20	9	A/C	500	173.6	226.8	0
27-Apr	56,600	56.7	20	10	A/C	500	173.2	225.8	0
28-Apr	55,500	No	Operation	Due to	No Am. Shad	Passed	at	Holtwood	
29-Apr	57,400	No	Operation	Due to	No Am. Shad	Passed	at	Holtwood	
30-Apr	56,600	55.8	18	9	A/C	500	173.1	226.6	0
1-May	50,100	55.3	24	9	A/C	500	172.6	226.9	0
2-May	45,600	56.6	24	6	A/C	500	171.6	227.0	0
3-May	41,900	60.2	20	6	A/C	500	171.3	226.7	1
4-May	39,900	64.2	20	6	A/C	500	171	226.0	1
5-May	38,200	66.2	18	7	A/C	500	171	226.8	61
6-May	36,900	66.4	18	5	A/C	500	170.7	227.0	76
7-May	36,700	65	18	6	A/C	500	170.9	226.5	79
8-May	38,000	65	18	6	A/C	500	170.9	226.5	125
9-May	39,700	66	18	6	A/C	500	170.8	226.0	62
10-May	38,900	68.1	18	6	A/C	500	170.8	226.2	89
11-May	37,000	67.9	18	6	A/C	500	170.8	226.3	33
12-May	35,600	68.8	18	3	A/C	500	170.4	225.5	27
13-May	39,600	68.3	18	7	A/C	500	170.8	225.1	45
14-May	65,400	66	16	6	A/C	500	172	225.1	54
15-May	99,500	No	Operation	Due to	River Flows	≥ 100,000	cfs from	15-25 May	
16-May	101,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	15-25 May	
17-May	107,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	15-25 May	
18-May	112,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	15-25 May	
19-May	102,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	15-25 May	
20-May	106,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	15-25 May	
21-May	100,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	15-25 May	
22-May	86,700	No	Operation	Due to	River Flows	≥ 100,000	cfs from	15-25 May	
23-May	85,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	15-25 May	
24-May	144,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	15-25 May	
25-May	126,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	15-25 May	
26-May	95,400	66.6	6	7	A/C	500	174	226.8	0
27-May	74,700	69.7	10	8	A/C	500	173.7	226.4	0
28-May	61,400	70.4	18	5	A/C	500	172.5	226.7	0
29-May	54,400	69.2	10	6	A/C	500	172.7	225.6	0
30-May	50,200	70	15	6	A/C	500	172.1	226.5	4
31-May	46,600	73	10	5	A/C	500	171.7	227.0	0
1-Jun	43,000	73	12	5	A/C	500	171.6	226.1	1
2-Jun	41,200	73	10	7	A/C	500	171.7	226.0	0
3-Jun	39,400	75.7	12	6	A/C	500	171.8	226.6	1
4-Jun	37,600	74.2	10	7	A/C	500	172.1	226.4	0
5-Jun	35,300	71.8	10	7	A/C	500	171.9	226.3	0
6-Jun	38,100	70.5	10	6	A/C	500	171.9	225.0	1
7-Jun	32,800	70.5	10	6	A/C	500	171.5	226.4	0
8-Jun	29,200	71.1	10	6	A/C	500	171.7	226.8	1

¹ River flow measured at USGS Marietta Gauge. NA: information not available

Table 3. Summary of American Shad passage counts and percent passage values at Susquehanna River dams, 1997-2018.

	Conowingo East	Holtwood*		Safe Harbor		York Haven	
		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	77.14%	907	7.14%
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	63.4%	3,896	73.7%	43	1.1%
2016	14,276	6,718	47.1%	4,242	63.1%	178	4.2%
2017	16,265	3,170	19.5%	2,007	63.3%	62	3.1%
2018	6,992	1,458	20.9%	661	45.3%	NA	NA

*Am. Shad passed at Holtwood from April 30 to June 6.

Table 4. Hourly summary of daily American Shad passage at the Safe Harbor fish passage facility in 2018.

Date:	4/26	4/27	4/28	4/29	4/30	5/1	5/2	5/3	5/4	5/5	5/6	5/7	
Observation Time-Start:	7:30	8:00			8:00	7:40	8:00	8:00	8:00	7:45	7:30	8:00	
Observation Time-End:	17:25	17:00			14:10	17:40	16:50	17:30	17:00	17:30	16:25	16:50	
Military Time (hrs)													
0600 to 0659													
0700 to 0759	0					0				0	3		
0800 to 0859	0	0			0	0	0	0	0	2	6	1	
0900 to 0959	0	0			0	0	0	0	1	2	7	1	
1000 to 1059	0	0			0	0	0	0	0	12	8	0	
1100 to 1159	0	0			0	0	0	0	0	5	13	9	
1200 to 1259	0	0			0	0	0	0	0	3	10	17	
1300 to 1359	0	0			0	0	0	0	0	8	7	12	
1400 to 1459	0	0			0	0	0	0	0	4	3	15	
1500 to 1559	0	0				0	0	1	0	9	16	17	
1600 to 1659	0	0				0	0	0	0	9	3	7	
1700 to 1759	0					0		0		7			
1800 to 1859													
1900 to 1959													
Total	0	1	1	61	76	79							

Date:	5/8	5/9	5/10	5/11	5/12	5/13	5/14	5/15	5/16	5/17	5/18	5/19	
Observation Time-Start:	7:30	8:00	7:20	8:00	7:20	8:00	7:30						
Observation Time-End:	16:30	16:40	17:40	17:35	17:25	17:30	16:55						
Military Time (hrs)													
0600 to 0659													
0700 to 0759	4		14		0		2						
0800 to 0859	15	9	18	2	2	5	9						
0900 to 0959	3	10	4	4	5	5	8						
1000 to 1059	4	6	3	4	6	6	1						
1100 to 1159	11	5	3	4	1	7	2						
1200 to 1259	18	2	8	2	1	4	6						
1300 to 1359	25	1	7	7	3	5	2						
1400 to 1459	22	10	12	0	2	5	5						
1500 to 1559	11	17	9	6	2	2	8						
1600 to 1659	12	2	11	4	2	5	11						
1700 to 1759			0	0	3	1							
1800 to 1859													
1900 to 1959													
Total	125	62	89	33	27	45	54	0	0	0	0	0	

Table 4. (Continued)

Date:	5/20	5/21	5/22	5/23	5/24	5/25	5/26	5/27	5/28	5/29	5/30	5/31	6/1
Observation Time-Start:							8:00	8:30	7:30	8:00	8:00	8:00	8:00
Observation Time-End:							16:25	16:00	15:45	16:15	16:20	16:30	16:15
Military Time (hrs)													
0600 to 0659													
0700 to 0759									0				
0800 to 0859							0	0	0	0	1	0	0
0900 to 0959							0	0	0	0	0	0	1
1000 to 1059							0	0	0	0	2	0	0
1100 to 1159							0	0	0	0	1	0	0
1200 to 1259							0	0	0	0	0	0	0
1300 to 1359							0	0	0	0	0	0	0
1400 to 1459							0	0	0	0	0	0	0
1500 to 1559							0	0	0	0	0	0	0
1600 to 1659							0			0	0	0	0
1700 to 1759													
1800 to 1859													
1900 to 1959													
Total	0	4	0	1									

Date:	6/2	6/3	6/4	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	Season Total	
Observation Time-Start:	8:00	7:40	8:00	8:00	8:00	8:00	8:00							
Observation Time-End:	16:15	17:00	17:00	17:00	16:50	16:15	15:50							
Military Time (hrs)														
0600 to 0659													0	
0700 to 0759		0											23	
0800 to 0859	0	0	0	0	0	0	0						70	
0900 to 0959	0	0	0	0	0	0	1						52	
1000 to 1059	0	0	0	0	1	0	0						53	
1100 to 1159	0	0	0	0	0	0	0						61	
1200 to 1259	0	0	0	0	0	0	0						71	
1300 to 1359	0	0	0	0	0	0	0						77	
1400 to 1459	0	0	0	0	0	0	0						78	
1500 to 1559	0	0	0	0	0	0	0						98	
1600 to 1659	0	1	0	0	0	0							67	
1700 to 1759													11	
1800 to 1859													0	
1900 to 1959													0	
Total	0	1	0	0	1	0	1	0	0	0	0	0	661	