

**SUMMARY OF OPERATIONS AT THE
SAFE HARBOR FISH PASSAGE FACILITY
SPRING 2015**

December 2015

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Prepared for

**SAFE HARBOR WATER POWER
BROOKFIELD RENEWABLE ENERGY GROUP**

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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. The Brookfield Renewable Energy Group is now the sole owner/operator of the Safe Harbor Hydroelectric Station.

Objectives for 2015 operation were to (1) monitor passage of migratory and resident fishes through the fishway; and (2) assess fishway effectiveness.

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 regulating 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 2015 season utilized a combination of entrances A and C.

2.2.2 Fishway Operation

Safe Harbor fishway operation commences soon after passage of approximately 500 American shad via the Holtwood fishway. In 2015, operations commenced on 4 May, two days after Holtwood passed 83 American shad into Lake Aldred.

The Safe Harbor fishway began operation on 4 May, with operations ending on 5 June. Lift operations ended due to the dwindling fish catch and rising water temperatures; indications that the migration run was ending.

Throughout the 2015 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. On 29 May, the crowder bridge drive motor brake coil failed. In order to avoid loss of fishing time and since the season was nearing its end, it was decided to place the crowder in the "fish" position with the crowder doors in "trap" position to allow fish access to the hopper area. Fish lift operations continued to the end of the season without crowding capabilities. Following the fishing season, Safe Harbor replaced the coil and the problem has been resolved.

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 2015 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 2015 by the Safe Harbor fishway is presented in Table 1. A total of 316,306 fish of 20 species and 1 hybrid passed upstream into Lake Clarke. Gizzard shad (306,543) was the dominant species passed and comprised nearly 97% of the catch. Some 3,896 American shad were passed upstream through the fishway and comprised 1.2% of the catch. Other predominant fishes passed included quillback (1,480), channel catfish (1,154), shorthead redhorse (1,011), smallmouth bass (989), and walleye (972). Peak passage occurred on 17 May, when 40,082 fish, (99% gizzard shad), were passed.

3.2 American Shad Passage

The Safe Harbor fishway passed 3,896 American shad in 2015 during 33 days of operation (Tables 1 and 2). This year's passage of American shad (3,896) is the seventh lowest in nineteen years of operation (Table 3). Safe Harbor managed to pass 73.7% of the American shad passed at Holtwood Dam and nearly 47% of the American shad passed by Conowingo Dam, (Table 3). Peak shad passage occurred on 8 May, when 397 American shad were captured and passed during 9.5 hours of operation. American shad passage on 6, 7, and 8 May accounted for nearly 30% of the total season's passage.

American shad were passed at water temperatures of 61.3°F to 80.3°F and river flows of 13,200 to 33,700cfs (Table 2 and Figures 1 and 2). River flows were relatively low in May 2015 resulting in no spillage or suspension of fish passage operations. Water temperature reached 70° F on 8 May and ranged between 70° and 80° F for the remainder of the season, excepting 3 days (23-25 May).

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 consistent from 0800 hrs to 1600 hrs. Passage sharply declined after 1600 hrs. The highest passage hour for American shad during the entire season was observed between 0800 hrs to 0859 hrs, with a total of 546 American shad passed. The highest hourly passage (93) occurred between 0800 hrs and 0859 hrs on 6 May.

During the 2015 season, the Safe Harbor fishway passed two American shad with blue (2015) MD DNR floy tags that had been passed by downstream fish lift facilities.

Passage of other alosids, (alewife, blueback herring, and hickory shad), at the Safe Harbor fishway was not observed in 2015.

4.0 SUMMARY

Aside from the crowder problem stated previously, the 2015 Safe Harbor fishway operating season was conducted with minimal disruptions to operations due to mechanical problems.

A total of 3,896 American shad were passed into Lake Clarke, or nearly 74% of the American shad that were passed into Lake Aldred by the Holtwood fishway (Table 3). Ninety percent of the total American shad passed at Safe Harbor occurred prior to 20 May (Figure 2), similar to when Holtwood passed 90% of their American shad season total (21 May). Future operations of the fishway will build on the past nineteen 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.

TABLES AND FIGURES

Table 1**Number and disposition of fish passed daily by the Safe Harbor fishway in 2015.**

Date	5/4	5/5	5/6	5/7	5/8	5/9	5/10	5/11	5/12	5/13
Start Viewing Time	8:20	7:35	8:00	7:40	8:00	7:15	8:00	7:25	8:00	7:30
End Viewing Time	16:25	17:25	17:30	17:20	17:30	17:30	17:30	17:40	17:30	17:35
Elapsed Viewing Time	8.1	9.8	9.5	9.7	9.5	10.3	9.5	10.3	9.5	10.1
Lifts Per Day	8	18	15	16	15	13	16	15	13	14
Water Temperature (F)	61.3	65	66.2	68	70	70.5	72	73.4	75.4	75
AMERICAN SHAD	95	294	371	386	397	264	195	206	112	166
GIZZARD SHAD	8,548	5,535	7,989	17,165	8,978	10,240	8,264	17,440	9,378	24,310
STRIPED BASS	0	3	0	3	0	0	0	0	0	0
SEA LAMPREY	0	0	0	0	0	0	0	0	0	0
BROWN TROUT	0	0	0	0	0	0	0	2	0	0
MUSKELLUNGE	0	0	1	0	1	0	0	0	0	0
CARP	0	0	6	3	55	4	12	31	4	7
QUILLBACK	6	162	130	81	207	89	125	123	71	186
S. REDHORSE	71	319	127	58	103	44	51	69	52	15
CHANNEL CATFISH	2	22	15	36	36	38	27	80	36	83
HYBRID STRIPED BASS	0	0	0	1	0	0	0	0	0	0
ROCK BASS	0	5	0	0	0	1	0	0	0	1
PUMKINSEED	0	0	0	0	0	0	0	0	0	0
BLUEGILL	0	2	2	0	1	1	0	1	1	2
SMALLMOUTH BASS	195	296	104	133	79	49	34	35	8	5
LARGEMOUTH BASS	3	0	1	1	0	0	0	0	0	0
WHITE CRAPPIE	0	0	0	0	0	1	0	0	0	0
BLACK CRAPPIE	0	0	0	0	0	0	0	0	0	0
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0
WALLEYE	12	94	79	68	53	24	27	52	14	50
FLATHEAD CATFISH	0	0	0	0	2	0	1	0	0	0
TOTALS	8,932	6,732	8,825	17,935	9,912	10,755	8,736	18,039	9,676	24,825

Table 1 (continued)

Date	5/14	5/15	5/16	5/17	5/18	5/19	5/20	5/21	5/22	5/23
Start Viewing Time	8:00	8:30	8:00	7:30	8:00	7:30	8:00	7:30	8:00	7:40
End Viewing Time	17:30	17:30	17:30	17:35	17:30	17:30	17:30	16:30	16:30	16:45
Elapsed Viewing Time	9.5	9.0	9.5	10.1	9.5	10.0	9.5	9.0	8.5	9.1
Lifts Per Day	15	16	16	18	21	20	19	13	16	14
Water Temperature (F)	73.1	72.9	70.3	71.6	73.8	73.3	75.2	74.5	71.9	68.9
AMERICAN SHAD	119	185	183	185	250	137	40	17	14	32
GIZZARD SHAD	30,224	24,617	17,414	39,685	13,309	12,395	9,744	803	8,699	4,919
STRIPED BASS	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	0	0	0	0	0	0	0	0
BROWN TROUT	0	0	0	0	1	0	0	0	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0
CARP	16	0	0	5	8	11	4	7	0	3
QUILLBACK	91	14	8	123	9	25	1	17	0	0
S. REDHORSE	26	3	20	14	8	12	13	1	0	1
CHANNEL CATFISH	24	23	22	18	34	78	77	110	28	5
HYBRID STRIPED BASS	0	0	0	0	0	0	0	0	0	0
ROCK BASS	0	0	1	1	2	1	2	0	0	0
PUMKINSEED	0	0	0	0	0	0	0	0	1	0
BLUEGILL	0	3	1	2	0	2	0	0	2	0
SMALLMOUTH BASS	12	3	3	5	12	2	6	2	1	0
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	0	0
WHITE CRAPPIE	0	0	0	0	0	0	0	0	0	0
BLACK CRAPPIE	0	0	0	0	0	0	0	0	0	0
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0
WALLEYE	31	45	22	44	56	77	18	19	6	7
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	1
TOTALS	30,543	24,893	17,674	40,082	13,689	12,740	9,905	976	8,751	4,968

Table 1 (continued)

Date	5/24	5/25	5/26	5/27	5/28	5/29	5/30	5/31	6/1	6/2
Start Viewing Time	8:00	7:40	8:00	8:45	8:00	7:45	8:00	7:45	8:00	7:30
End Viewing Time	16:30	16:30	16:30	16:30	16:30	15:35	16:30	16:30	16:30	16:30
Elapsed Viewing Time	8.5	8.8	8.5	7.8	8.5	7.8	8.5	8.8	8.5	9.0
Lifts Per Day	11	13	9	10	11	9	9	10	11	13
Water Temperature (F)	68.4	68	71	72.5	76.6	79	77.3	79.5	80.1	80.3
AMERICAN SHAD	23	73	44	35	26	17	7	11	0	8
GIZZARD SHAD	1,971	1,001	1,784	3,715	2,287	2,738	1,001	1,385	1,925	3,302
STRIPED BASS	0	0	0	1	0	0	0	0	0	2
SEA LAMPREY	0	0	0	0	0	0	0	0	0	1
BROWN TROUT	0	0	0	0	0	0	0	0	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0
CARP	0	0	2	2	2	0	0	1	0	1
QUILLBACK	0	0	0	0	0	0	1	0	2	2
S. REDHORSE	2	1	0	0	0	0	1	0	0	0
CHANNEL CATFISH	5	7	18	121	42	9	13	22	15	55
HYBRID STRIPED BASS	0	0	0	0	0	0	0	0	0	0
ROCK BASS	2	0	0	0	0	0	0	0	0	0
PUMKINSEED	0	0	0	0	0	0	0	0	0	0
BLUEGILL	0	0	3	2	0	1	1	1	2	2
SMALLMOUTH BASS	0	0	0	1	1	2	0	1	0	0
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	0	0
WHITE CRAPPIE	0	0	0	0	0	0	0	0	0	0
BLACK CRAPPIE	0	0	0	0	0	0	0	0	0	0
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0
WALLEYE	1	11	9	33	33	18	1	17	11	16
FLATHEAD CATFISH	0	0	1	0	0	0	0	1	0	0
TOTALS	2,004	1,093	1,861	3,910	2,391	2,785	1,025	1,439	1,955	3,389

Table 1 (continued)

Date	6/3	6/4	6/5	Season Total
Start Viewing Time	7:30	8:00	7:30	
End Viewing Time	16:30	16:30	15:30	
Elapsed Viewing Time	9.0	8.5	8.0	300
Lifts Per Day	13	10	10	450
Water Temperature (F)	78.5	75.3	71.8	
AMERICAN SHAD	4	0	0	3,896
GIZZARD SHAD	2,981	2,721	76	306,543
STRIPED BASS	0	0	0	9
SEA LAMPREY	0	0	0	1
BROWN TROUT	0	0	0	3
MUSKELLUNGE	0	0	0	2
CARP	0	0	0	184
QUILLBACK	7	0	0	1,480
S. REDHORSE	0	0	0	1,011
CHANNEL CATFISH	43	8	2	1,154
HYBRID STRIPED BASS	0	0	0	1
ROCK BASS	0	0	0	16
PUMKINSEED	0	0	0	1
BLUEGILL	0	0	0	32
SMALLMOUTH BASS	0	0	0	989
LARGEMOUTH BASS	0	0	0	5
WHITE CRAPPIE	0	0	0	1
BLACK CRAPPIE	0	0	0	0
YELLOW PERCH	0	0	0	0
WALLEYE	20	0	4	972
FLATHEAD CATFISH	0	0	0	6
TOTALS	3,055	2,729	82	316,306

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 2015.

Date	River Flow¹ (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
4-May	33,700	61.3	18	6	A/C	500	170.7	227.1	95
5-May	30,900	65	18	3	A/C	500	170.1	227.3	294
6-May	28,700	66.2	18	NA	A/C	500	169.7	226.6	371
7-May	27,400	68	18	NA	A/C	500	169.8	227.3	386
8-May	26,000	70	18	NA	A/C	500	170.2	226.7	397
9-May	25,100	70.5	18	NA	A/C	500	169.1	226.7	264
10-May	24,300	72	18	3	A/C	500	167.5	226.8	195
11-May	22,800	73.4	18	3	A/C	500	167.9	226.5	206
12-May	21,000	75.4	18	3	A/C	500	167.4	225.8	112
13-May	19,500	75	15	3	A/C	500	167.2	226.6	166
14-May	18,500	73.1	15	4	A/C	500	167.7	227.2	119
15-May	17,900	72.9	24	5	A/C	500	169.5	226.8	185
16-May	18,800	70.3	18	6	A/C	500	169.4	227.1	183
17-May	19,600	71.6	20	3	A/C	500	169.2	227.2	185
18-May	19,500	73.8	20	NA	A/C	500	170.2	227.0	250
19-May	23,300	73.3	20	NA	A/C	500	168.9	227.0	137
20-May	25,700	75.2	18	NA	A/C	500	169.5	227.0	40
21-May	23,400	74.4	16	NA	A/C	500	170.9	226.7	17
22-May	25,100	71.9	13	NA	A/C	500	169.6	226.4	14
23-May	27,000	68.9	14	NA	A/C	500	167.8	227.0	32
24-May	24,200	68.2	10	NA	A/C	500	169.0	227.1	23
25-May	21,100	68	15	NA	A/C	500	168.1	227.2	73
26-May	19,000	71	18	3	A/C	500	169.0	227.4	44
27-May	17,100	72.5	16	NA	A/C	500	170.4	226.4	35
28-May	16,700	76.6	18	NA	A/C	500	168.9	226.6	26
29-May	15,200	79	18	3	A/C	500	168.7	226.8	17
30-May	14,300	77.3	18	2	A/C	500	167.9	226.6	7
31-May	13,200	79.5	16	NA	A/C	500	168.9	227.1	11
1-Jun	14,000	80.1	18	4	A/C	500	168.9	227.0	0
2-Jun	19,400	80.3	18-15	NA	A/C	500	169.5	227.3	8
3-Jun	21,600	78.5	15	NA	A/C	500	168.5	227.2	4
4-Jun	25,700	75.3	18	NA	A/C	500	168.4	227.2	0
5-Jun	22,800	71.8	15	2	A/C	500	168.3	227.2	0

1 River flow measured at USGS Marietta Guage.

NA: information not available

Table 3**Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2015.**

	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	43.63%	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	63.3%	3,896	73.7%	43	1.1%

*Am. Shad passed at Holtwood from May 1 to June 2.

Table 4

Hourly summary of daily American shad passage at the Safe Harbor fish passage facility in 2015.

<i>Date:</i>	5/4	5/5	5/6	5/7	5/8	5/9	5/10	5/11	5/12	5/13	5/14	5/15
<i>Observation Time-Start:</i>	8:20	7:35	8:00	7:40	8:00	7:15	8:00	7:25	8:00	7:30	8:00	8:30
<i>Observation Time-End:</i>	16:25	17:25	17:30	17:20	17:30	17:30	17:30	17:40	17:30	17:35	17:30	17:30
Military Time (hrs)												
0600 to 0659												
0700 to 0759		8		34		7		11		7		
0800 to 0859	17	42	93	57	86	39	44	10	18	13	5	0
0900 to 0959	30	31	70	54	59	24	34	13	13	9	10	23
1000 to 1059	9	21	37	48	58	28	18	31	11	18	11	25
1100 to 1159	4	37	17	36	14	33	32	24	9	17	7	22
1200 to 1259	15	41	14	32	19	36	13	27	17	11	23	15
1300 to 1359	9	35	39	17	53	28	11	20	14	19	24	25
1400 to 1459	4	25	17	29	39	24	15	12	12	22	8	17
1500 to 1559	1	13	48	41	39	27	9	35	8	36	14	13
1600 to 1659	6	24	25	22	14	7	14	12	6	8	11	27
1700 to 1759		17	11	16	16	11	5	11	4	6	6	18
1800 to 1859												
1900 to 1959												
Total	95	294	371	386	397	264	195	206	112	166	119	185

<i>Date:</i>	5/16	5/17	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25	5/26	5/27
<i>Observation Time-Start:</i>	8:00	7:30	8:00	7:30	8:00	7:30	8:00	7:40	8:00	7:40	8:00	8:45
<i>Observation Time-End:</i>	17:30	17:35	17:30	17:30	17:30	16:30	16:30	16:45	16:30	16:30	16:30	16:30
Military Time (hrs)												
0600 to 0659												
0700 to 0759		18		2		2		0		0		
0800 to 0859	14	28	46	5	6	2	5	1	0	7	3	0
0900 to 0959	19	8	19	15	3	1	2	2	2	10	14	5
1000 to 1059	17	18	38	9	5	1	0	1	7	6	7	7
1100 to 1159	33	23	22	11	5	2	3	3	7	13	6	7
1200 to 1259	24	17	20	24	0	3	0	9	0	10	2	4
1300 to 1359	19	21	21	15	4	3	3	3	1	9	0	8
1400 to 1459	17	4	21	18	5	2	0	6	5	10	4	1
1500 to 1559	8	20	32	9	5	1	0	4	1	7	6	3
1600 to 1659	28	16	25	25	6	0	1	3	0	1	2	0
1700 to 1759	4	12	6	4	1							
1800 to 1859												
1900 to 1959												
Total	183	185	250	137	40	17	14	32	23	73	44	35

Table 4

Continued.

<i>Date:</i>	5/28	5/29	5/30	5/31	6/1	6/2	6/3	6/4	6/5	<i>Season Total</i>
<i>Observation Time-Start:</i>	8:00	7:45	8:00	7:45	8:00	7:30	7:30	8:00	7:30	
<i>Observation Time-End:</i>	16:30	15:35	16:30	16:30	16:30	16:30	16:30	16:30	15:30	
Military Time (hrs)										
0600 to 0659										0
0700 to 0759		0		0		1	2		0	92
0800 to 0859	2	2	0	1	0	0	0	0	0	546
0900 to 0959	0	0	0	1	0	1	0	0	0	472
1000 to 1059	0	0	0	2	0	0	0	0	0	433
1100 to 1159	9	2	0	0	0	1	1	0	0	400
1200 to 1259	4	2	2	0	0	1	0	0	0	385
1300 to 1359	9	3	1	1	0	2	0	0	0	417
1400 to 1459	0	5	0	0	0	0	0	0	0	322
1500 to 1559	1	3	2	5	0	2	0	0	0	393
1600 to 1659	1		2	1	0	0	1	0	0	288
1700 to 1759										148
1800 to 1859										0
1900 to 1959										0
Total	26	17	7	11	0	8	4	0	0	3,896

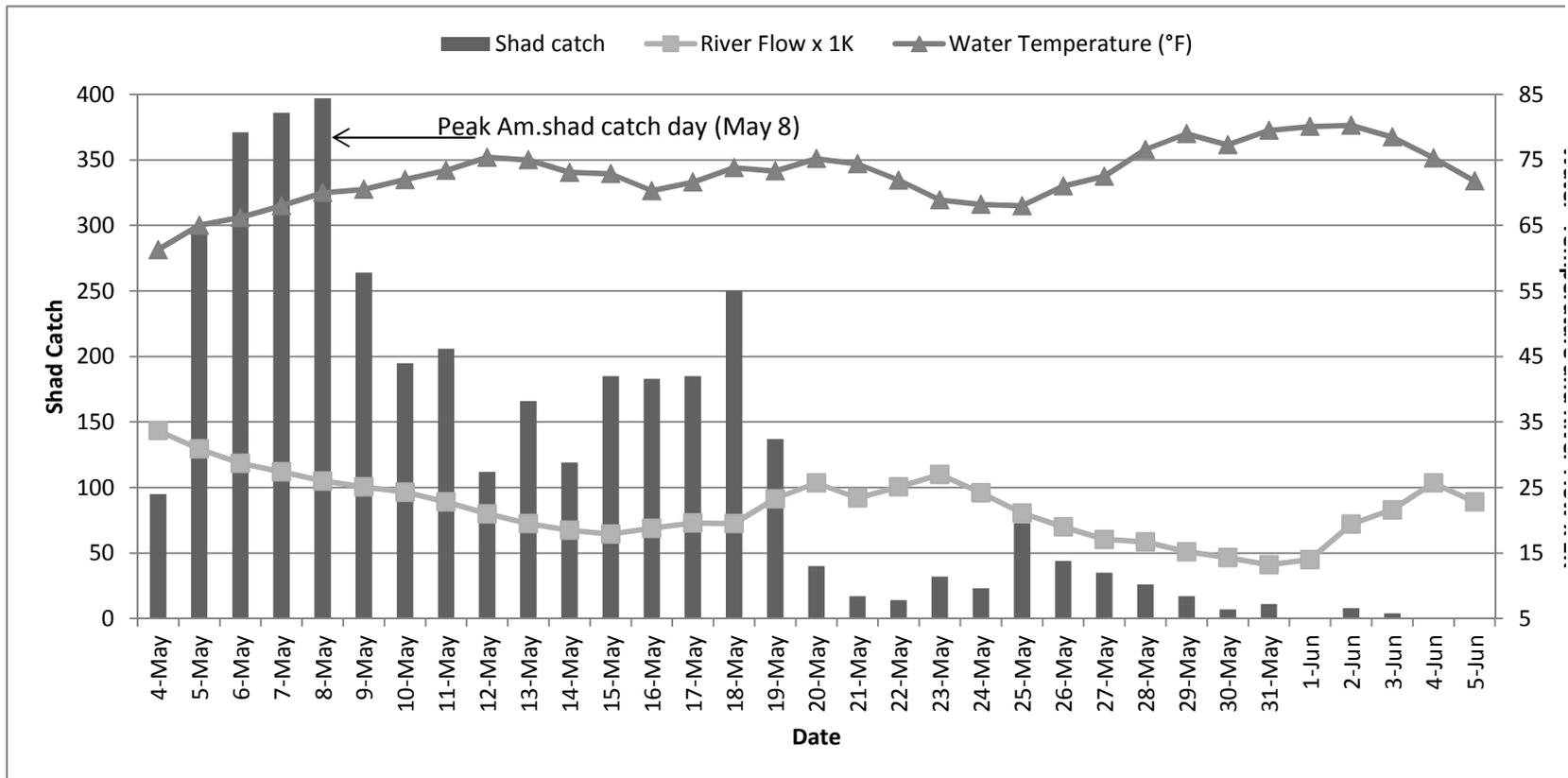


Figure 1

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 2015.

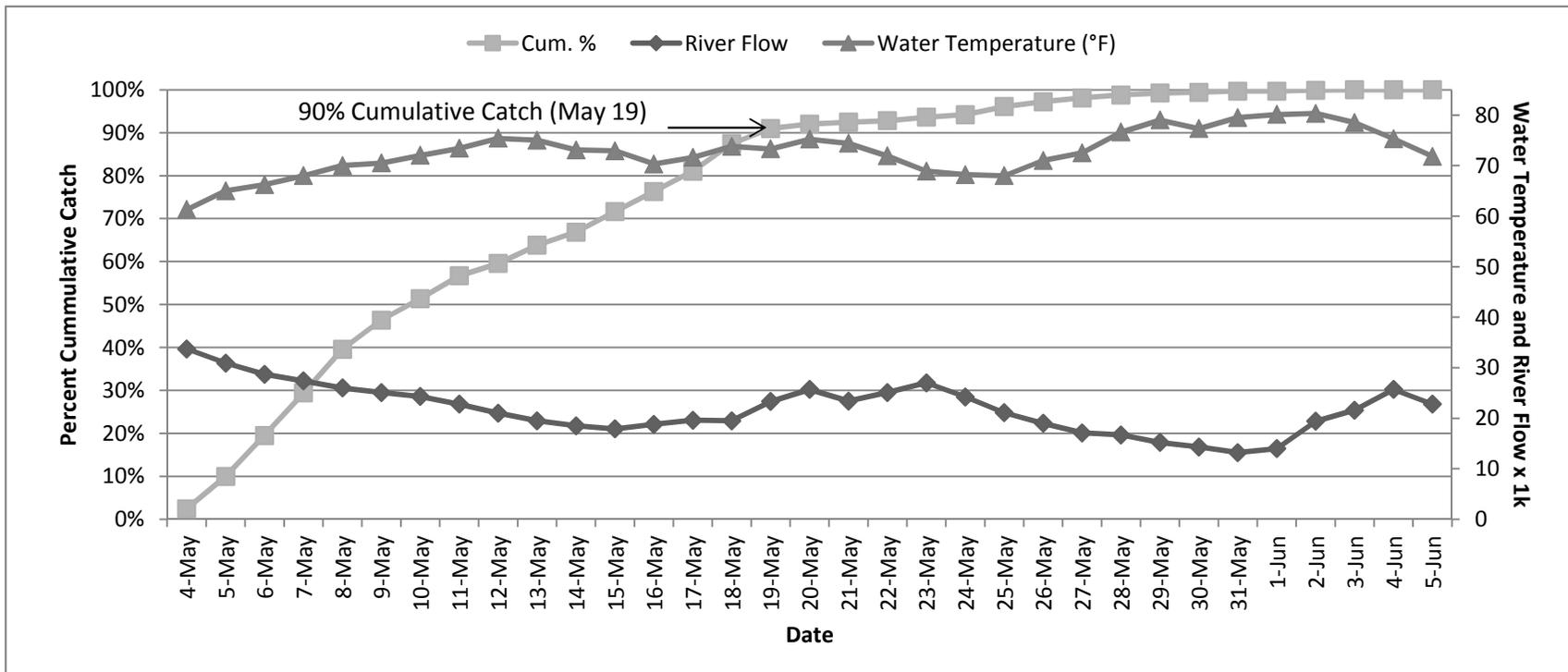


Figure 2

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 2015.