

**SUMMARY OF OPERATIONS AT THE
SAFE HARBOR FISH PASSAGE FACILITY
SPRING 2014**

December 2014

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

Objectives for 2014 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 (4,725 gal. capacity), 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 2014 season utilized a combination of entrances A and C (Table 2).

2.2.2 Fishway Operation

Safe Harbor fishway operation commences soon after passage of approximately 500 American shad via the Holtwood fishway. In 2014, operations commenced on 1 May, four days after Holtwood passed 75 American shad into Lake Aldred.

The Safe Harbor fishway began operation on 1 May, with operations ending on 11 June. Lift operations ended due to the dwindling fish catch and rising water temperatures; indications that the migration run was ending.

Throughout the 2014 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, SHWPC performed maintenance activities that included periodic cleaning of the exit channel, daily inspections, cleaning of picket screens, and other routine maintenance activities. On May 15, the crowder doors were damaged during operations. In order to avoid loss of fishing time, it was decided to place the crowder in the "fish" position with the crowder doors open 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 repaired the damaged crowder doors. Safe Harbor was unable to duplicate the problem which caused the damage, but at this time we believe the problem to be 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 biologist or 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 2014 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 2014 by the Safe Harbor fishway is presented in Table 1. A total of 225,312 fish of 20 species and 1 hybrid passed upstream into Lake Clarke. Gizzard shad (216,826) was the dominant species passed and comprised 96% of the catch. Some 1,336 American shad were passed upstream through the fishway and comprised nearly 0.6% of the catch. Other predominant fishes passed included channel catfish (2,642), walleye (1,358), and shorthead redhorse (1,037). Peak passage occurred on 13 May, when 17,578 fish, (95% gizzard shad), were passed.

3.2 American Shad Passage

The Safe Harbor fishway passed 1,336 American shad in 2014 during 37 days of operation (Tables 1 and 2). This year's passage of American shad (1,336) is the third lowest in eighteen years of operation (Table 3). Safe Harbor managed to pass 51.6% of the American shad passed at Holtwood Dam and nearly 13% of the American shad passed by Conowingo Dam, (Table 3). Peak shad passage occurred on 15 May, when 280 American shad were captured and passed during 10 hours of operation.

American shad were passed at water temperatures of 53.2°F to 78.3°F and river flows of 22,800 to 106,000 cfs (Table 2 and Figures 1 and 2). River flows greater than 110,000 cfs occurred from 17 to 21 May resulting in spillage and the suspension of fish passage operations. Water temperature was relatively stable (remained below 70.0°) from 1 May to 1 June. After 1 June, the water temperatures steadily climbed to the end of the season.

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 1659 hrs. Passage sharply declined after 1700 hrs. The highest passage hour for American shad during the entire season was observed between 1400 hrs to 1459 hrs, with a total of 159 American shad passed. The highest hourly passage (44) occurred between 1400 hrs and 1459 hrs on 15 May.

During the 2014 season, the Safe Harbor fishway passed no MD DNR tagged American shad 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 2014.

4.0 SUMMARY

Aside from the crowder problem stated previously, the 2014 Safe Harbor fishway operating season was conducted with minimal disruptions to operations due to mechanical problems. Safe Harbor did discover during the fishing season that the brass drive nuts for opening and closing the entrance gates were failing. A temporary repair was made during the season and all 3 entrance gates now have new nuts installed.

A total of 1,336 American shad were passed into Lake Clarke, or nearly 52% of the American shad that were passed into Lake Aldred by the Holtwood fishway (Table 3). More than 90% of the total American shad passed at Safe Harbor occurred prior to 16 May (Figure 2), the same day that

Holtwood passed 90% of their American shad season total (16 May). Future operations of the fishway will build on the past eighteen 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 2014.**

Date	5/1	5/2	5/3	5/4	5/5	5/6	5/7	5/8	5/9	5/10
Start Viewing Time	8:30	7:40	8:00	7:40	8:00	8:00	7:40	8:00	9:15	7:40
End Viewing Time	17:10	17:00	16:45	16:50	16:45	17:15	17:00	17:00	16:45	17:00
Elapsed Viewing Time	8.7	9.3	8.8	9.2	8.8	9.3	9.3	9.0	7.5	9.3
Lifts Per Day	13	12	12	12	13	14	13	12	10	15
Water Temperature (F)	53.2	54.9	57.7	57	55.6	56.8	59	60	60	62
AMERICAN SHAD	3	1	9	14	9	17	21	16	39	59
GIZZARD SHAD	1,865	198	1,503	943	2,845	1,060	1,495	2,735	2,278	9,538
STRIPED BASS	2	0	0	1	0	0	0	0	0	0
SEA LAMPREY	0	0	0	0	0	0	0	0	0	0
RAINBOW TROUT	0	0	0	1	0	0	0	0	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0
CARP	0	0	0	1	6	10	2	10	15	59
QUILLBACK	2	0	1	1	0	1	60	40	36	64
S. REDHORSE	3	3	23	18	17	70	143	75	107	85
CHANNEL CATFISH	9	0	0	0	0	0	4	10	1	35
HYBRID STRIPED BASS	0	0	0	1	0	0	0	0	0	0
ROCK BASS	2	0	0	0	0	0	0	0	0	4
PUMKINSEED	0	0	0	0	0	0	0	0	0	1
BLUEGILL	0	0	0	0	0	0	0	0	0	2
SMALLMOUTH BASS	3	3	30	15	8	28	42	45	25	84
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	6	2	5	7	2	9	35	40	8	87
FLATHEAD CATFISH	0	0	2	0	0	0	0	0	0	0
TOTALS	1,895	207	1,573	1,002	2,887	1,195	1,802	2,971	2,509	10,018

Table 1 (continued)

Date	5/11	5/12	5/13	5/14	5/15	5/16	5/22	5/23	5/24	5/25
Start Viewing Time	8:00	7:40	8:00	8:00	8:00	7:40	8:15	8:00	7:45	8:00
End Viewing Time	16:45	17:10	17:15	16:45	17:30	18:00	17:00	16:45	16:50	16:45
Elapsed Viewing Time	8.8	9.5	9.3	8.8	9.5	10.3	8.8	8.8	9.1	8.8
Lifts Per Day	11	15	13	13	14	14	7	13	13	13
Water Temperature (F)	65	66.4	68.4	69.1	69.4	69.3	60	61	62.6	63
AMERICAN SHAD	35	213	229	192	280	83	0	6	4	1
GIZZARD SHAD	7,495	10,996	16,750	11,228	14,900	12,231	275	295	1,354	635
STRIPED BASS	0	0	0	0	0	0	0	0	0	0
SEA LAMPREY	0	0	1	0	0	0	0	0	0	0
RAINBOW TROUT	1	0	1	0	0	0	0	0	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0
CARP	36	26	25	49	55	9	1	0	3	2
QUILLBACK	78	96	70	134	95	16	0	0	0	0
S. REDHORSE	69	104	110	90	55	7	0	0	0	0
CHANNEL CATFISH	41	64	65	43	40	53	5	3	11	13
HYBRID STRIPED BASS	0	0	0	0	0	0	0	0	0	0
ROCK BASS	1	2	2	0	3	0	0	0	0	0
PUMKINSEED	0	0	0	0	0	0	0	0	0	0
BLUEGILL	1	2	0	2	0	3	0	0	0	0
SMALLMOUTH BASS	53	120	120	39	25	14	0	0	0	1
LARGEMOUTH BASS	0	0	0	1	1	0	0	0	0	0
WHITE CRAPPIE	0	0	0	0	0	1	0	0	0	0
BLACK CRAPPIE	0	0	0	0	1	0	0	0	0	0
YELLOW PERCH	5	0	0	0	0	0	0	0	0	0
WALLEYE	26	152	205	83	125	54	1	0	0	0
FLATHEAD CATFISH	1	0	0	0	0	0	0	0	0	0
TOTALS	7,842	11,775	17,578	11,861	15,580	12,471	282	304	1,372	652

Table 1 (continued)

Date	5/26	5/27	5/28	5/29	5/30	5/31	6/1	6/2	6/3	6/4
Start Viewing Time	7:40	8:00	9:00	8:30	7:45	8:15	7:45	8:00	7:45	7:30
End Viewing Time	17:00	16:30	16:50	16:30	16:50	16:30	16:35	16:45	17:00	16:30
Elapsed Viewing Time	9.3	8.5	7.8	8.0	9.1	8.3	8.8	8.8	9.3	9.0
Lifts Per Day	13	12	12	10	13	12	12	13	13	12
Water Temperature (F)	66	68	69	70	67.5	67.1	68.5	70	73	74
AMERICAN SHAD	5	1	0	7	3	2	4	2	12	10
GIZZARD SHAD	7,979	7,900	12,035	6,600	6,736	7,587	6,310	7,470	8,155	5,462
STRIPED BASS	0	0	0	0	1	0	0	0	0	0
SEA LAMPREY	0	0	0	0	0	0	0	0	0	0
RAINBOW TROUT	1	0	0	0	0	0	0	0	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0
CARP	8	40	5	1	0	0	3	6	20	4
QUILLBACK	2	35	10	17	0	0	8	26	42	14
S. REDHORSE	0	15	9	3	1	1	1	5	6	1
CHANNEL CATFISH	70	170	188	305	86	28	68	100	205	204
HYBRID STRIPED BASS	0	0	0	0	0	0	0	0	0	0
ROCK BASS	1	0	0	0	0	0	1	0	0	0
PUMKINSEED	0	0	0	0	0	0	1	0	2	0
BLUEGILL	0	0	1	0	0	0	6	0	4	1
SMALLMOUTH BASS	1	7	11	6	1	1	3	2	9	2
LARGEMOUTH BASS	0	0	2	0	0	0	0	2	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	6	35	81	70	15	27	18	50	28	23
FLATHEAD CATFISH	0	0	0	1	1	0	0	0	0	0
TOTALS	8,073	8,203	12,342	7,010	6,844	7,646	6,423	7,663	8,483	5,721

Table 1 (continued)

Date	6/5	6/6	6/7	6/8	6/9	6/10	6/11	
Start Viewing Time	7:45	8:00	7:35	7:30	7:45	8:00	8:00	Season
End Viewing Time	16:40	16:30	16:40	16:30	16:40	16:45	16:15	Total
Elapsed Viewing Time	8.9	8.5	9.1	9.0	8.9	8.8	8.3	246.7
Lifts Per Day	13	13	12	13	12	12	8	420
Water Temperature (F)	76	75.6	75.2	76.3	77	77	78.3	
AMERICAN SHAD	4	13	9	3	8	19	3	1,336
GIZZARD SHAD	8,413	9,600	6,535	6,421	2,427	6,550	27	216,826
STRIPED BASS	0	0	1	0	0	1	0	6
SEA LAMPREY	0	0	0	0	0	0	0	1
RAINBOW TROUT	0	0	0	0	0	0	0	4
MUSKELLUNGE	1	0	0	0	0	0	0	1
CARP	3	0	1	1	3	3	1	408
QUILLBACK	43	6	2	0	0	2	19	920
S. REDHORSE	5	2	1	0	1	4	3	1,037
CHANNEL CATFISH	182	85	92	41	86	145	190	2,642
HYBRID STRIPED BASS	0	0	0	0	0	0	0	1
ROCK BASS	0	0	0	0	0	0	0	16
PUMKINSEED	0	0	0	0	0	1	0	5
BLUEGILL	3	0	0	0	1	0	0	26
SMALLMOUTH BASS	0	2	3	0	1	1	0	705
LARGEMOUTH BASS	0	0	0	0	0	0	0	6
WHITE CRAPPIE	0	0	0	0	0	0	0	1
BLACK CRAPPIE	0	0	0	0	0	0	0	1
YELLOW PERCH	0	0	0	0	0	0	0	5
WALLEYE	24	35	41	15	7	27	9	1,358
FLATHEAD CATFISH	0	1	0	0	1	0	0	7
TOTALS	8,678	9,744	6,685	6,481	2,535	6,753	252	225,312

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 2014.

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)
1-May	76,100	53.2	6-8	12	A	500	175.4	225.6
2-May	70,800	54.9	6	12	A/C	500	175.5	225.8
3-May	67,700	57.7	6	11	A/C	500	173.3	226.4
4-May	67,900	57	15	10	A/C	500	172.6	226.7
5-May	63,100	55.5	12	10	A/C	500	173.0	226.5
6-May	57,000	56.8	20-24	12	A/C	500	172.3	226.8
7-May	52,200	59	24	9	A/C	500	171.8	226.9
8-May	47,200	60	24	NA	A/C	500	171.2	226.9
9-May	42,700	60	24	NA	A/C	500	171.7	226.8
10-May	39,300	62	24	NA	A/C	500	170.1	227.0
11-May	37,800	62	20	6	A/C	500	171.4	226.7
12-May	34,800	66.4	20	7	A/C	500	170.2	226.8
13-May	34,400	68.4	24	8	A/C	500	171.9	226.8
14-May	34,400	69.1	12	7	A/C	500	171.3	226.8
15-May	32,500	69.4	20	NA	A/C	500	172.6	226.4
16-May	47,600	69.3	18-15	NA	A/C	500	171.7	226.7
17-May	158,000					500		
18-May	193,000					500		
19-May	177,000					500		
20-May	138,000					500		
21-May	112,000					500		
22-May	95,800	60	6	12	A/C	500	176.0	226.2
23-May	106,000	61	6	12	A/C	500	176.2	226.4
24-May	103,000	62.6	6-8	12	A/C	500	175.5	226.4
25-May	85,000	63	6	11	A/C	500	174.8	226.7
26-May	70,300	66	10	10	A/C	500	174.4	226.9
27-May	58,900	68	20	9	A/C	500	174.1	226.4
28-May	53,200	69	20	9	A/C	500	173.4	226.7
29-May	47,600	70	20	10	A/C	500	170.3	226.8
30-May	44,000	67.5	14	7	A/C	500	170.4	226.8
31-May	41,400	67.1	24-16	6	A/C	500	171.4	226.4
1-Jun	36,400	68.5	20-12	6	A/C	500	170.7	227.2
2-Jun	31,900	70	18-20	6	A/C	500	170.4	226.4
3-Jun	28,800	73	18	5	A/C	500	169.8	226.7
4-Jun	26,800	74	20-16	4	A/C	500	169.6	226.8
5-Jun	25,100	76	20-18	5	A/C	500	169.8	226.6
6-Jun	26,200	75.6	18-16	5	A/C	500	169.1	227.1
7-Jun	25,700	75.2	16	6	A/C	500	169.2	226.8
8-Jun	23,700	76.3	16	NA	A/C	500	169.5	226.7
9-Jun	22,800	77	16	NA	A/C	500	170	226.8
10-Jun	24,500	77	16	5	A/C	500	169.9	226.6
11-Jun	25,200	78.3	16	5	A/C	500	169.8	226.8

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, 1997-2014.**

	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%

Table 4

Hourly summary of daily American shad passage at the Safe Harbor fish passage facility in 2014.

<i>Date:</i>	5/1	5/2	5/3	5/4	5/5	5/6	5/7	5/8	5/9	5/10	5/11	5/12
<i>Observation Time-Start:</i>	8:30	7:40	8:00	7:40	8:00	8:00	7:40	8:00	9:15	7:40	8:00	7:40
<i>Observation Time-End:</i>	17:10	17:00	16:45	16:50	16:45	17:15	17:00	17:00	16:45	17:00	16:45	17:10
Military Time (hrs)												
0600 to 0659	0	0	0	0	0	0	0	0	0			
0700 to 0759	0	0	0	0	0	0	0	0	0	0		0
0800 to 0859	0	0	1	3	1	1	0	0	0	4	6	23
0900 to 0959	1	0	2	1	0	0	0	0	2	7	4	38
1000 to 1059	0	0	2	4	0	0	4	5	6	6	3	19
1100 to 1159	0	0	0	3	1	0	3	2	7	13	5	17
1200 to 1259	0	1	1	0	0	0	2	1	6	5	2	16
1300 to 1359	0	0	0	1	0	0	4	1	4	8	2	19
1400 to 1459	1	0	2	2	3	1	5	2	4	9	6	15
1500 to 1559	0	0	0	0	2	7	0	1	7	3	3	30
1600 to 1659	1	0	1	0	2	4	3	4	3	4	4	28
1700 to 1759	0	0	0		0	4	0	0	0			8
1800 to 1859												
1900 to 1959												
Total	3	1	9	14	9	17	21	16	39	59	35	213

<i>Date:</i>	5/13	5/14	5/15	5/16	5/22	5/23	5/24	5/25	5/26	5/27	5/28	5/29
<i>Observation Time-Start:</i>	8:00	8:00	8:00	7:40	8:15	8:00	7:45	8:00	7:40	8:00	9:00	8:30
<i>Observation Time-End:</i>	17:15	16:45	17:30	18:00	17:00	16:45	16:50	16:45	17:00	16:30	16:50	16:30
Military Time (hrs)												
0600 to 0659												
0700 to 0759				8			1		2			
0800 to 0859	24	15	30	13	0	0	1	0	0	0		
0900 to 0959	31	31	26	5	0	1	0	0	0	0	0	1
1000 to 1059	15	13	33	9	0	0	1	0	0	0	0	0
1100 to 1159	36	26	27	4	0	1	0	0	0	0	0	1
1200 to 1259	15	28	30	4	0	1	0	0	1	1	0	3
1300 to 1359	10	29	21	6	0	1	0	0	0	0	0	1
1400 to 1459	26	10	44	15	0	0	1	0	1	0	0	1
1500 to 1559	28	15	37	8	0	2	0	0	0	0	0	0
1600 to 1659	30	25	17	2	0	0	0	1	1	0	0	0
1700 to 1759	14		15	9								
1800 to 1859												
1900 to 1959												
Total	229	192	280	83	0	6	4	1	5	1	0	7

Table 4

Continued.

<i>Date:</i>	5/30	5/31	6/1	6/2	6/3	6/4	6/5	6/6	6/7	6/8	6/9	6/10
<i>Observation Time-Start:</i>	7:45	8:15	7:45	8:00	7:45	7:30	7:45	8:00	7:35	7:30	7:45	8:00
<i>Observation Time-End:</i>	16:50	16:30	16:35	16:45	17:00	16:30	16:40	16:30	16:40	16:30	16:40	16:45
Military Time (hrs)												
0600 to 0659												
0700 to 0759	0		0		0		0		2	0	2	
0800 to 0859	0	1	1	0	0	0	0	0	2	0	1	0
0900 to 0959	0	1	0	0	0	0	0	0	1	0	0	0
1000 to 1059	1	0	1	0	0	2	1	2	0	0	2	3
1100 to 1159	0	0	0	0	1	0	0	1	0	0	2	5
1200 to 1259	1	0	1	1	2	6	0	1	0	2	1	3
1300 to 1359	0	0	0	0	2	0	1	0	2	0	0	3
1400 to 1459	1	0	0	0	4	1	1	1	1	0	0	2
1500 to 1559	0	0	1	1	2	1	1	6	1	0	0	0
1600 to 1659	0	0	0	0	1	0	0	2	0	1	0	3
1700 to 1759												
1800 to 1859												
1900 to 1959												
Total	3	2	4	2	12	10	4	13	9	3	8	19

<i>Date:</i>	6/11	
<i>Observation Time-Start:</i>	8:00	<i>Season</i>
<i>Observation Time-End:</i>	16:15	<i>Total</i>
Military Time (hrs)		
0600 to 0659		0
0700 to 0759		15
0800 to 0859	2	129
0900 to 0959	0	152
1000 to 1059	0	132
1100 to 1159	0	155
1200 to 1259	1	136
1300 to 1359	0	115
1400 to 1459	0	159
1500 to 1559	0	156
1600 to 1659	0	137
1700 to 1759		50
1800 to 1859		0
1900 to 1959		0
Total	3	1,336

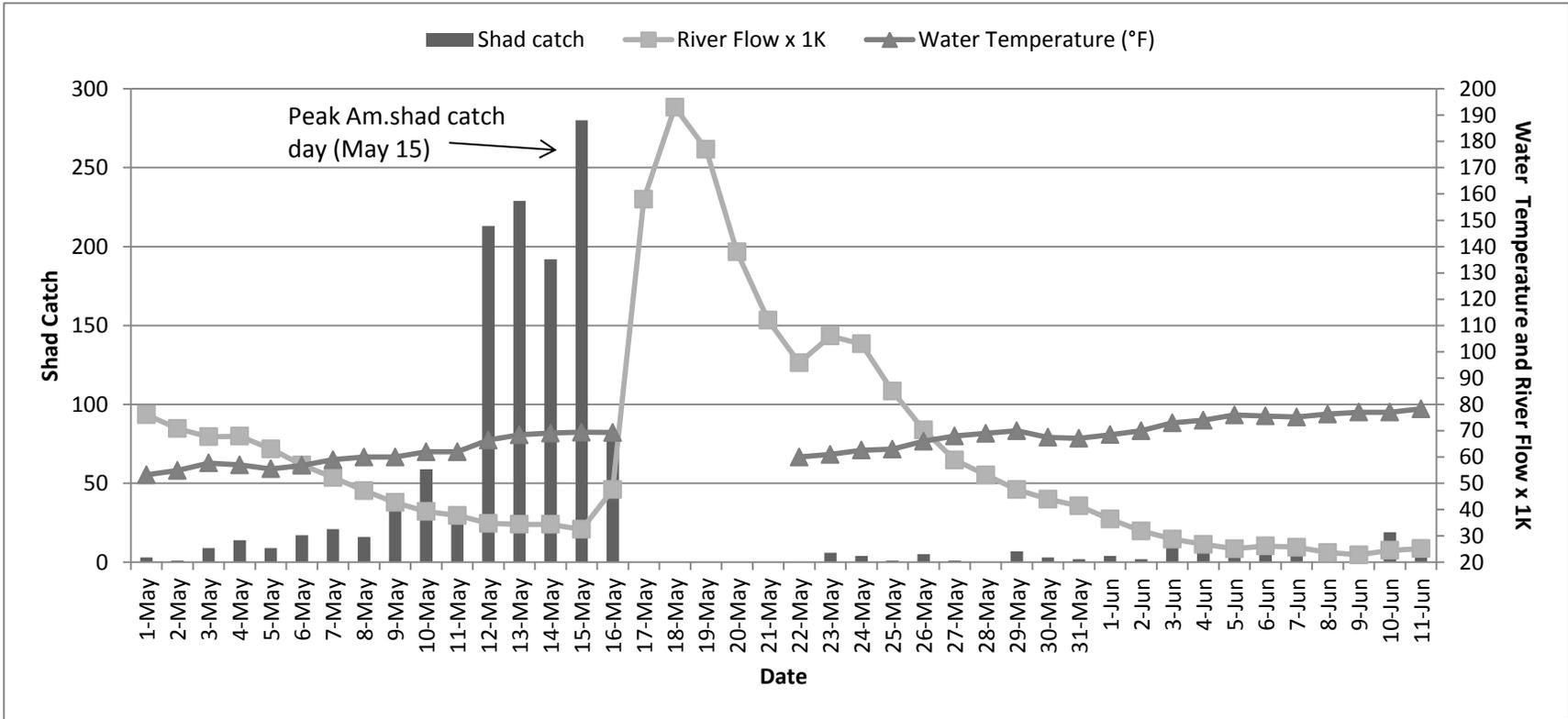


Figure 1

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 2014.

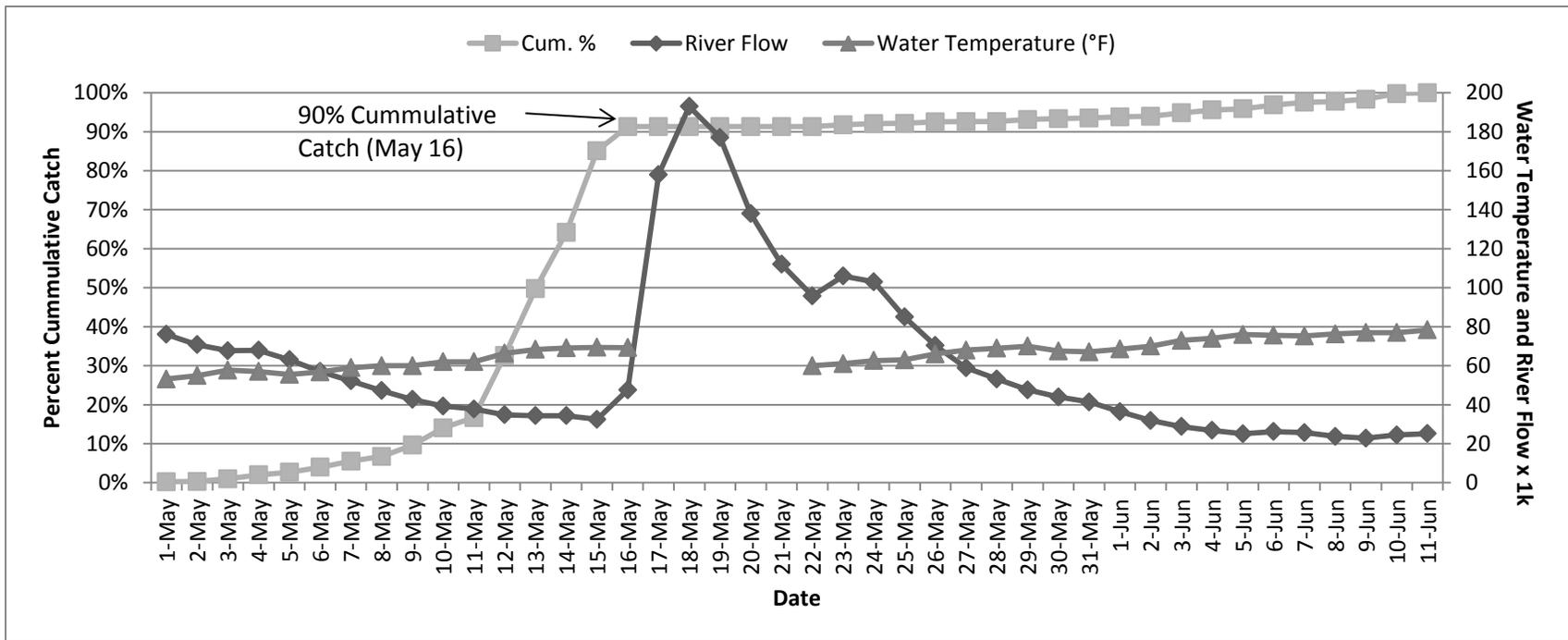


Figure 2

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 2014.