SUMMARY OF OPERATIONS AT THE SAFE HARBOR FISH PASSAGE FACILITY SPRING 2013

November 2013

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November 2013

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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.

Objectives for 2013 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 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 2013 season utilized a combination of entrances A, B, and C or A and C (Table1).

2.2.2 Fishway Operation

Safe Harbor fishway operation commences soon after passage of approximately 500 American shad via the Holtwood fishway. In 2013, operations commenced on May 1, two days after Holtwood passed 224 American shad into Lake Aldred.

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

Throughout the 2013 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. Mechanical and/or electrical problems were addressed as needed.

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 and/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 reducing the channel width at the counting window from 36 in down to 18 in (and a range of intermediate widths) was adjusted as viewing conditions and fish passage dictated. For the entire 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 to a portable electronic memory device (flash drive) and stored on 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 daily in 2013 by the Safe Harbor fishway is presented in Table 2. A total of 361,904 fish of 20 species passed upstream into Lake Clarke. Gizzard shad (348,753) was the dominant species passed and comprised 96% of the catch. American shad (1,927), along with quillback (3,577), walleye (2,060), channel catfish (1,794), shorthead redhorse (1,325), smallmouth bass (1,260), and carp (1,023) comprised 3.5% of the remaining total catch. The highest fish passage day occurred on May 12, when 27,713 fish, (98.5% gizzard shad), were passed upstream into Lake Clarke during 10 hours of operation.

3.2 American Shad Passage

The Safe Harbor fishway passed 1,927 American shad in 2013 during 41 days of operation (Tables 1and 2). This year's passage of American shad (1,927) is the third lowest in seventeen years of operation (Table 3). Safe Harbor managed to pass 77% of the American shad passed at Holtwood Dam and 15% of the American shad passed by Conowingo Dam, (Table 3). Peak shad passage occurred on May 10, when 246 American shad were captured and passed during 8.3 hours of operation.

American shad were passed at water temperatures of 59.4°F to 80.1°F and river flows of 19,300 to 48,000 cfs (Table 1 and Figures 1 and 2). Water temperature was relatively stable (generally remained below 70.0°F) from May 1 to May 30. After May 30, the water temperature steadily climbed and remained above 73°F to season end.

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 peak passage hour for American shad during the entire season was observed between 1400 hrs to 1459 hrs, with a total of 274 American shad passed. The highest hourly passage (44) occurred between 1400 hrs and 1459 hrs on May 11.

During the 2013 season, the Safe Harbor fishway passed one American shad with a pink floy tag from this years' tagging effort by MD DNR downstream of Conowingo Dam.

Passage of other alosids, (alewife, blueback herring, and hickory shad), at the Safe Harbor fishway was not observed in 2013.

4.0 SUMMARY

The 2013 Safe Harbor fishway operating season was conducted with minimal disruptions to operations due to mechanical problems.

A total of 1,927 American shad was passed into Lake Clarke, or 77% 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 May 26 (Figure 2), shortly after Holtwood passed 90% of their American shad season total (May 24). Future operations of the fishway will build on the past seventeen 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

Summary of daily average river flow and water temperature as measured at USGS Gauge Marietta, turbidity (secchi), unit operation, entrance gates utilized, attraction flow, and project water elevations during operation of the Safe Harbor fish passage facility in 2013.

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)
1-May	34,700	59.4	24	8	A/C	500	170.8	226.5
2-May	32,200	60.8	24	8	A/C	500	169.5	226.6
3-May	29,800	62.2	24	5	A/C	500	170.1	226.9
4-May	28,000	64	24	6	A/C	500	169.6	227.0
5-May	26,300	65.1	24	6	A/C	500	170.1	226.7
6-May	24,100	65.3	24	5	A/C	500	169.4	226.8
7-May	22,700	65	24	4	A/B/C	500	168.9	227.1
8-May	22,000	65	22	4	A/B/C	500	168.9	227.1
9-May	26,000	65	20	6	A/C	500	170.0	227.2
10-May	32,600	68	28	6	A/C	500	172.3	226.4
11-May	36,500	68	22	6	A/C	500	171.0	226.5
12-May	40,200	68.5	20	6	A/C	500	171.6	227.0
13-May	47,200	66	22	8	A/C	500	173.0	227.0
14-May	48,000	61	24	10	A/C	500	173.6	226.1
15-May	43,600	61	24	7	A/C	500	174.0	226.5
16-May	38,900	59.9	22	7	A/C	500	171.6	226.7
17-May	34,900	63.1	20	5	A/C	500	170.5	226.7
18-May	31,500	65.5	20	6	A/C	500	170.2	227.0
19-May	28,300	67.3	20	5	A/C	500	171.2	226.8
20-May	25,900	66.9	25	5	A/C	500	170.6	226.8
21-May	23,800	68	30	5	A/C	500	171.1	226.4
22-May	21,500	70.5	30	5	A/C	500	171.1	226.7
23-May	20,900	73	30	4	A/C	500	169.3	226.6
24-May	20,700	75.1	28	5	A/C	500	171.5	226.9
25-May	21,700	70	15	4	A/C	500	171.7	226.9
26-May	20,700	68.5	15	4	A/C	500	170.5	226.9
27-May	21,900	64.8	15	4	A/C	500	169.4	226.9
28-May	24,100	65.1	20	5	A/C	500	170.4	227.0
29-May	23,300	64.8	20	5	A/C	500	169.6	227.2
30-May	23,000	70	24	5	A/C	500	170.1	226.7
31-May	27,500	73	24	5	A/C	500	171.5	226.7
1-Jun	29,100	77.6	22-18	5	A/C	500	171.5	227.0
2-Jun	30,300	80	20		A/C	500	172.6	226.8
3-Jun	34,300	80.1	24	7	A/C	500	172.8	226.5
4-Jun	30,700	78.8	24	6	A/C	500	171.9	226.6
5-Jun	25,500	76.1	24	6	A/C	500	171.4	226.6
6-Jun	21,900	77.1	26	6	A/C	500	171.2	226.4
7-Jun	20,700	75.2	24	7	A/C	500	173.1	226.3
8-Jun	20,400	73.6	24	5	A/C	500	170.1	226.5
9-Jun	19,300	73	15	9	A/C	500	169.9	227
11-Jun	19,300	73.5	15	5	A/C	500	170.9	226.7

1 River flow measured at USGS Marietta Guage.

Table 2

Number and disposition of fish passed daily by the Safe Harbor fishway in 2013.

Date:	1-May	2-May	3-May	4-May	5-May	6-May	7-May	8-May	9-May	10-May	11-May
Viewing Start Time:	8:00	7:30	7:30	7:40	7:30	7:30	7:50	8:00	7:30	11:00	7:30
Viewing End Time:	17:40	17:00	16:45	17:00	17:00	16:59	17:30	17:00	17:00	19:20	17:45
Hours of Operation:	9.7	9.5	9.3	9.3	9.5	9.5	9.7	9.0	9.5	8.3	10.3
Number of Lifts:	13	12	12	12	12	6	12	13	12	15	14
Water Temperature (°F):	59.4	60.8	62.2	64	65.1	65.3	65	65	65	68	68
AMERICAN SHAD	118	76	59	103	101	113	97	66	38	246	222
GIZZARD SHAD	7330	7449	3123	3470	4910	5531	6740	5250	6682	15957	13290
STRIPED BASS	0	0	0	0	0	0	0	0	2	0	0
RAINBOW TROUT	0	1	0	0	0	0	0	0	0	0	0
BROWN TROUT	0	0	0	0	0	0	0	0	1	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0	0
CARP	0	1	20	20	52	25	49	240	55	12	28
QUILLBACK	78	245	317	515	258	59	50	190	367	117	567
S. REDHORSE	96	147	96	165	78	9	11	15	33	14	135
CHANNEL CATFISH	2	1	2	11	18	4	18	10	35	128	287
ROCK BASS	1	0	6	2	4	1	3	1	3	15	10
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	0	0
PUMKINSEED	0	0	0	0	0	0	0	0	1	1	0
BLUEGILL	0	0	0	1	0	0	1	2	2	4	1
SMALLMOUTH BASS	323	275	168	100	38	17	60	20	27	41	82
LARGEMOUTH BASS	0	1	2	2	0	0	0	0	0	0	0
WHITE CRAPPIE	0	0	0	0	0	0	0	0	0	1	0
BLACK CRAPPIE	0	0	0	0	0	0	0	0	0	0	0
WALLEYE	45	112	78	155	119	13	78	30	84	139	195
NORTHERN PIKE	0	0	0	0	0	0	0	0	0	0	0
Daily Total	**7,993**	**8,308**	**3,871**	**4,544**	**5,578**	**5,772**	**7,107**	**5,824**	**7,330**	**16,675**	**14,817**

Table 2

Continued.

Date:	12-May	13-May	14-May	15-May	16-May	17-May	18-May	19-May	20-May	21-May	22-May
Viewing Start Time:	7:20	9:15	8:00	7:30	8:00	10:40	8:10	7:30	7:40	10:50	7:25
Viewing End Time:	17:20	17:00	16:50	20:00	16:45	17:00	16:45	16:50	17:00	16:45	16:45
Hours of Operation:	10.0	7.8	8.8	12.5	8.8	6.3	8.6	9.3	9.3	5.9	9.3
Number of Lifts:	19	12	11	16	12	10	12	15	20	12	16
Water Temperature (°F):	68.5	66	61	61	59.9	63.1	65.5	67.3	66.9	68	70.5
AMERICAN SHAD	153	68	54	17	44	20	9	8	13	17	28
GIZZARD SHAD	27307	12150	6050	2512	8570	5800	9245	25999	19130	14050	18205
STRIPED BASS	1	0	0	0	0	0	0	0	0	0	0
RAINBOW TROUT	0	0	0	0	0	0	0	0	0	0	0
BROWN TROUT	0	0	1	1	0	0	0	0	0	2	0
MUSKELLUNGE	0	1	0	0	0	0	0	0	0	0	0
CARP	7	2	7	2	5	58	57	43	17	11	9
QUILLBACK	35	2	1	0	3	40	41	169	83	8	26
S. REDHORSE	35	1	0	0	0	3	24	106	49	26	52
CHANNEL CATFISH	31	25	16	11	10	12	68	109	12	2	7
ROCK BASS	8	2	1	2	1	1	0	7	0	2	1
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	0	0
PUMKINSEED	0	0	0	0	0	0	0	0	0	0	0
BLUEGILL	3	6	0	0	0	0	1	0	0	1	5
SMALLMOUTH BASS	27	10	7	2	2	4	3	5	6	5	4
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	0	0	0
WHITE CRAPPIE	0	0	0	0	0	0	0	0	0	0	0
BLACK CRAPPIE	0	0	0	0	0	0	0	0	0	0	0
WALLEYE	106	17	8	11	26	29	66	177	53	14	51
NORTHERN PIKE	0	0	0	0	0	0	0	0	0	1	0
Daily Total	**27,713**	**12,284**	**6,145**	**2,558**	**8,661**	**5,967**	**9,514**	**26,623**	**19,363**	**14,139**	**18,388**

Table 2

Continued.

Date:	23-May	24-May	25-May	26-May	27-May	28-May	29-May	30-May	31-May	1-Jun	2-Jun
Viewing Start Time:	8:00	7:30	7:15	7:30	7:30	8:00	8:00	8:00	7:25	7:35	7:20
Viewing End Time:	16:45	17:13	17:00	17:30	16:50	18:45	17:25	16:45	16:45	16:45	17:05
Hours of Operation:	8.8	9.7	9.8	10.0	9.3	10.8	9.4	8.8	9.3	9.2	9.8
Number of Lifts:	16	12	14	14	14	11	12	11	13	12	13
Water Temperature (°F):	73	75.1	70	68.5	64.8	65.1	64.8	70	73	77.6	80
AMERICAN SHAD	30	22	22	49	24	5	17	22	12	18	17
GIZZARD SHAD	14300	18850	13990	2674	9106	116	5109	7900	5166	8644	8830
STRIPED BASS	0	0	0	0	0	0	0	0	0	0	0
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	2	0	0	0
CARP	20	38	23	17	5	1	12	36	28	9	14
QUILLBACK	155	135	33	2	0	0	0	7	8	11	23
S. REDHORSE	125	23	1	4	0	0	0	0	21	12	22
CHANNEL CATFISH	90	172	57	18	3	8	5	11	53	34	113
ROCK BASS	0	6	0	3	0	0	0	0	5	1	1
GREEN SUNFISH	0	0	0	0	0	0	0	0	0	2	0
PUMKINSEED	0	0	4	0	0	0	3	0	1	0	3
BLUEGILL	0	0	4	0	0	0	4	2	1	1	3
SMALLMOUTH BASS	15	8	1	1	1	0	1	2	0	2	1
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	0	0	0
WHITE CRAPPIE	0	0	1	0	0	0	0	0	0	0	0
BLACK CRAPPIE	0	0	0	0	0	0	0	0	0	0	0
WALLEYE	80	22	37	5	19	12	5	27	47	26	47
NORTHERN PIKE	0	0	0	0	0	0	0	0	0	0	0
Daily Total	**14,815**	**19,276**	**14,173**	**2,773**	**9,158**	**142**	**5,156**	**8,009**	**5,342**	**8,760**	**9,074**

Table 2

Continued.

Date:	3-Jun	4-Jun	5-Jun	6-Jun	7-Jun	8-Jun	9-Jun	11-Jun	
Viewing Start Time:	7:45	7:35	9:00	7:40	7:50	7:30	7:30	8:00	
Viewing End Time:	17:00	17:03	16:45	16:45	16:30	16:50	13:45	16:45	*Season*
Hours of Operation:	9.3	9.5	7.8	9.1	8.7	9.3	6.3	8.8	*Total*
Number of Lifts:	12	12	11	13	13	13	8	13	
Water Temperature (°F):	80.1	78.8	76.1	77.1	75.2	73.6	73	73.5	
AMERICAN SHAD	6	3	1	5	0	2	1	1	**1,927**
GIZZARD SHAD	7100	3893	1680	1007	2025	490	2493	6630	**348,753**
STRIPED BASS	0	0	0	0	0	0	0	0	**3**
RAINBOW TROUT	0	0	0	0	0	0	0	0	**1**
BROWN TROUT	0	0	0	0	0	0	0	0	**5**
MUSKELLUNGE	0	0	0	0	0	0	0	0	**3**
CARP	5	11	51	21	10	0	0	2	**1,023**
QUILLBACK	10	2	7	1	10	0	0	2	**3,577**
S. REDHORSE	5	11	2	3	0	0	0	1	**1,325**
CHANNEL CATFISH	75	86	68	54	70	17	13	28	**1,794**
ROCK BASS	0	0	0	0	0	0	0	0	**87**
GREEN SUNFISH	0	0	0	0	0	0	0	0	**2**
PUMKINSEED	0	1	0	1	0	0	0	0	**15**
BLUEGILL	10	3	0	0	0	0	0	2	**57**
SMALLMOUTH BASS	1	1	0	0	0	0	0	0	**1,260**
LARGEMOUTH BASS	1	0	0	0	0	0	0	2	**8**
WHITE CRAPPIE	0	0	0	0	0	0	0	0	**2**
BLACK CRAPPIE	0	0	0	1	0	0	0	0	**1**
WALLEYE	30	5	2	18	26	16	9	21	**2,060**
NORTHERN PIKE	0	0	0	0	0	0	0	0	**1**
Daily Total	**7,243**	**4,016**	**1,811**	**1,111**	**2,141**	**525**	**2,516**	**6,689**	**361,904**

Table 3

Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2013.

	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%**

Table 4

Hourly summary of daily American shad passage at the Safe Harbor fish passage facility in 2013.

Date:	*1-May*	*2-May*	*3-May*	*4-May*	*5-May*	*6-May*	*7-May*	*8-May*	*9-May*	*10-May*	*11-May*	*12-May*
Observation Time-Start:	*8:00*	*7:30*	*7:30*	*7:40*	*7:30*	*7:30*	*7:50*	*8:00*	*7:30*	*11:00*	*7:30*	*7:20*
Observation Time-End:	*17:40*	*17:00*	*16:45*	*17:00*	*17:00*	*16:59*	*17:30*	*17:00*	*17:00*	*19:20*	*17:45*	*17:20*
Military Time (hrs)												
0600 to 0659												
0700 to 0759		6	4	1	2	0	2		0		5	2
0800 to 0859	3	18	9	8	8	0	5	11	3		35	36
0900 to 0959	15	4	8	18	7	0	4	6	6		24	9
1000 to 1059	4	5	4	18	23	0	6	6	4	0	12	22
1100 to 1159	19	7	2	6	5	0	8	5	4	41	26	19
1200 to 1259	10	3	3	8	14	24	19	8	3	32	16	13
1300 to 1359	22	9	12	8	8	27	14	0	4	27	18	11
1400 to 1459	13	7	8	11	16	31	15	14	5	37	44	16
1500 to 1559	15	7	2	16	9	23	1	6	6	40	20	15
1600 to 1659	9	10	7	9	9	8	20	10	3	18	19	8
1700 to 1759	8						3			23	3	2
1800 to 1859										19		
1900 to 1959										9		
Total	**118**	**76**	**59**	**103**	**101**	**113**	**97**	**66**	**38**	**246**	**222**	**153**

Date:	*13-May*	*14-May*	*15-May*	*16-May*	*17-May*	*18-May*	*19-May*	*20-May*	*21-May*	*22-May*	*23-May*	*24-May*
Observation Time-Start:	*9:15*	*8:00*	*7:30*	*8:00*	*10:40*	*8:10*	*7:30*	*7:40*	*10:50*	*7:25*	*8:00*	*7:30*
Observation Time-End:	*17:00*	*16:50*	*20:00*	*16:45*	*17:00*	*16:45*	*16:50*	*17:00*	*16:45*	*16:45*	*16:45*	*17:13*
Military Time (hrs)												
0600 to 0659												
0700 to 0759			0				1	0		1		0
0800 to 0859		5	0	4		2	1	2		2	5	0
0900 to 0959	3	4	0	2		2	0	2		6	3	0
1000 to 1059	1	14	0	1	4	1	1	0	0	6	4	0
1100 to 1159	6	2	0	6	0	1	2	2	0	7	6	3
1200 to 1259	2	11	4	7	1	0	1	3	1	0	2	2
1300 to 1359	16	6	2	6	1	1	2	0	1	1	3	9
1400 to 1459	19	1	3	3	4	1	0	0	5	1	1	3
1500 to 1559	11	7	0	6	4	0	0	4	8	2	4	3
1600 to 1659	10	4	0	9	6	1	0	0	2	2	2	2
1700 to 1759			2									
1800 to 1859			0									
1900 to 1959			6									
Total	**68**	**54**	**17**	**44**	**20**	**9**	**8**	**13**	**17**	**28**	**30**	**22**

Table 4

Continued.

Date:	*25-May*	*26-May*	*27-May*	*28-May*	*29-May*	*30-May*	*31-May*	*1-Jun*	*2-Jun*	*3-Jun*	*4-Jun*	*5-Jun*
Observation Time-Start:	*7:15*	*7:30*	*7:30*	*8:00*	*8:00*	*8:00*	*7:25*	*7:35*	*7:20*	*7:45*	*7:35*	*9:00*
Observation Time-End:	*17:00*	*17:30*	*16:50*	*18:45*	*17:25*	*16:45*	*16:45*	*16:45*	*17:05*	*17:00*	*17:03*	*16:45*
Military Time (hrs)												
0600 to 0659												
0700 to 0759	3	0	1				0	0	1	0	0	
0800 to 0859	5	3	1	0	3	2	0	0	2	2	0	
0900 to 0959	2	14	3	1	4	1	2	4	0	0	2	0
1000 to 1059	2	10	1	1	2	4	0	0	0	2	0	0
1100 to 1159	1	3	0	0	2	2	2	2	5	1	0	1
1200 to 1259	2	8	6	0	2	1	1	3	2	0	0	0
1300 to 1359	1	4	7	0	3	1	2	4	1	0	0	0
1400 to 1459	1	1	1	3	0	6	1	2	1	0	0	0
1500 to 1559	4	5	3	0	1	2	3	0	4	0	0	0
1600 to 1659	1	1	1	0	0	3	1	3	1	1	1	0
1700 to 1759				0	0							
1800 to 1859				0								
1900 to 1959												
Total	**22**	**49**	**24**	**5**	**17**	**22**	**12**	**18**	**17**	**6**	**3**	**1**

Date:	*6-Jun*	*7-Jun*	*8-Jun*	*9-Jun*	*11-Jun*	
Observation Time-Start:	*7:40*	*7:50*	*7:30*	*7:30*	*8:00*	*Season*
Observation Time-End:	*16:45*	*16:30*	*16:50*	*13:45*	*16:45*	*Total*
Military Time (hrs)						
0600 to 0659						0
0700 to 0759	0	0	0	0		29
0800 to 0859	2	0	0	1	0	178
0900 to 0959	1	0	0	0	0	157
1000 to 1059	1	0	0	0	0	159
1100 to 1159	0	0	0	0	0	196
1200 to 1259	0	0	1	0	1	214
1300 to 1359	1	0	1	0	0	233
1400 to 1459	0	0	0		0	274
1500 to 1559	0	0	0		0	231
1600 to 1659	0	0	0		0	181
1700 to 1759						41
1800 to 1859						19
1900 to 1959						15
Total	**5**	**0**	**2**	**1**	**1**	**1927**

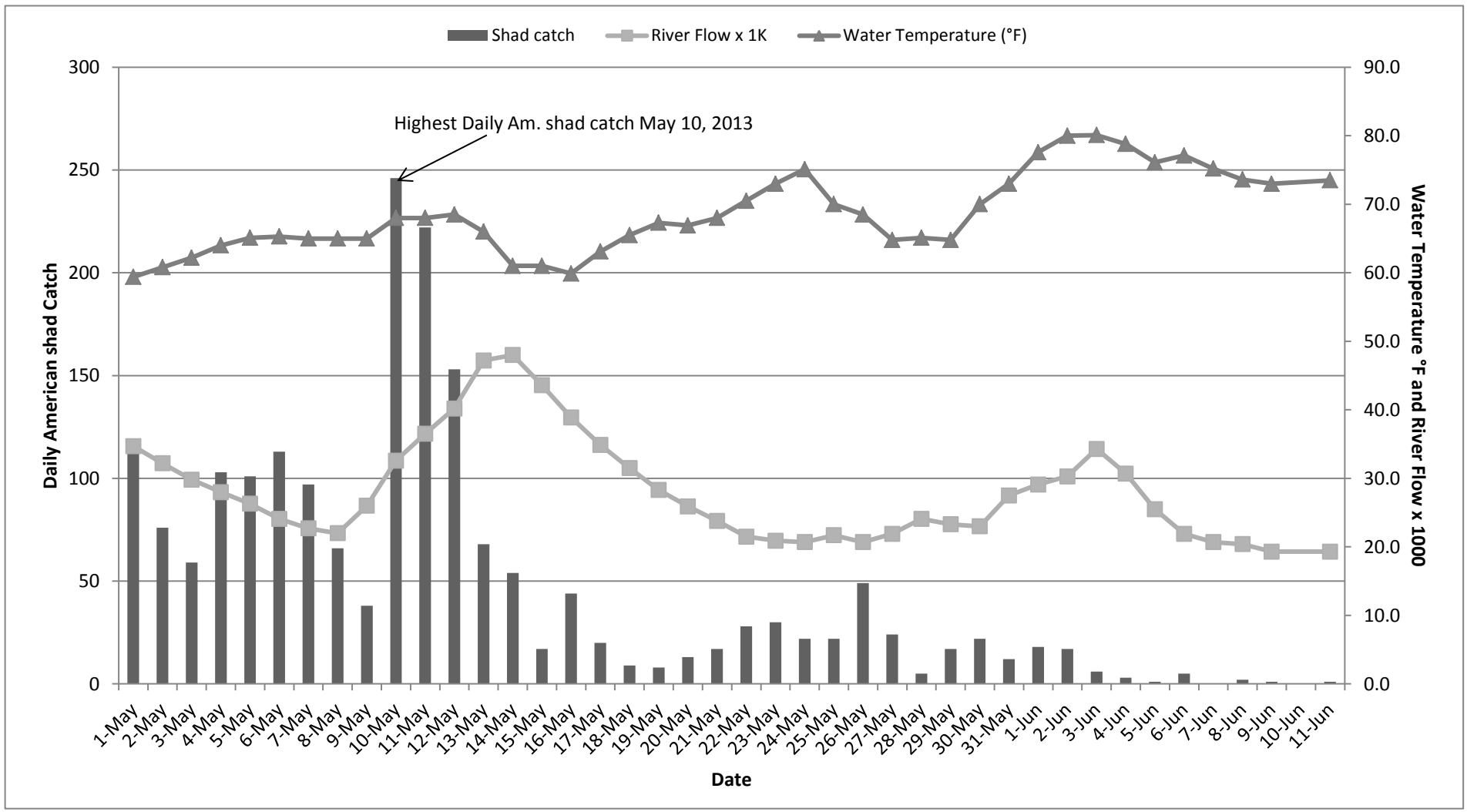

Figure 1

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 2013.

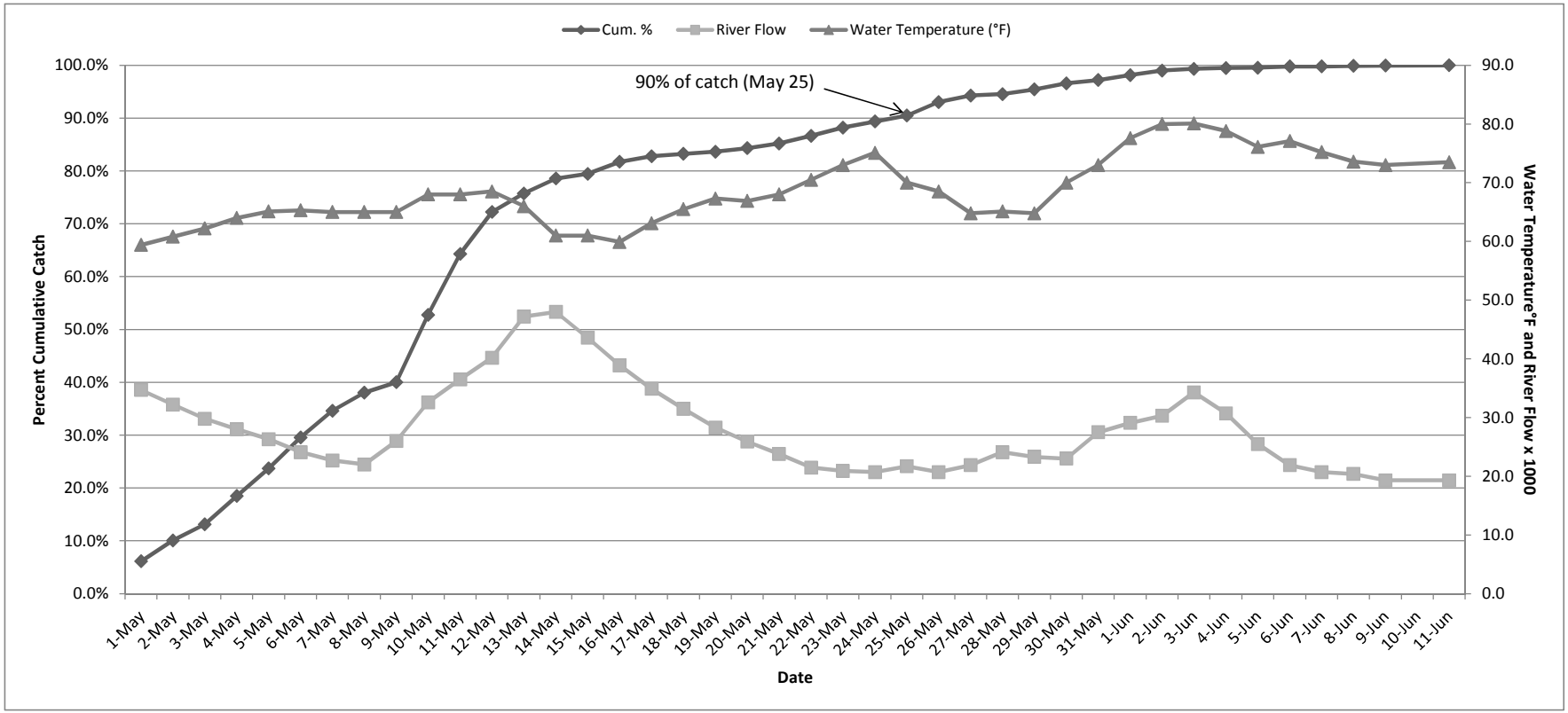

Figure 2

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 2013.