

**SUMMARY OF OPERATIONS AT THE
SAFE HARBOR FISH PASSAGE FACILITY
SPRING 2009**

November 2009

**SUMMARY OF OPERATIONS AT THE
SAFE HARBOR FISH PASSAGE FACILITY
SPRING 2009**

Prepared for

SAFE HARBOR WATER POWER CORPORATION

1 Powerhouse Road
Conestoga, Pennsylvania 17516

Prepared by

NORMANDEAU ASSOCIATES, INC.

1921 River Road
Drumore, Pennsylvania 17518

Normandeau Associates' Project Number 21468

November 2009

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 SAFE HARBOR OPERATION 1

 2.1 Project Operation 1

 2.2 Fishway Design and Operation 1

 2.2.1 Fishway Design 1

 2.2.2 Fishway Operation 2

 2.3 Fish Counts..... 2

3.0 RESULTS..... 3

 3.1 Relative Abundance 3

 3.2 American Shad Passage..... 3

 3.3 Alosids..... 3

4.0 SUMMARY 3

5.0 RECOMMENDATIONS 4

6.0 LITERATURE CITED..... 4

TABLES AND FIGURES

LIST OF TABLES AND FIGURES

Table 1 Number and disposition of fish passed by the Safe Harbor fishway in 2009.

Table 2 Summary of daily average river flow and water temperature as measured at Holtwood Dam, turbidity (secchi), unit operation, entrance gates utilized, attraction flow, and project water elevations during operation of the Safe Harbor fish passage facility in 2009.

Table 3 Hourly summary of American shad passage at the Safe Harbor fish passage facility in 2009.

Table 4 Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2009.

Figure 1 A plot of river flow and water temperature as measured at Holtwood Dam in relation to the daily American shad catch at the Safe Harbor fish passage facility, spring 2009.

Figure 2 A plot of river flow and water temperature as measured at Holtwood Dam in relation to the percent cumulative American shad catch at the Safe Harbor fish passage facility, spring 2009.

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 2009 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 over 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 2009 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 2009, operations commenced on 5 May, one day after Holtwood passed 1,003 American shad into Lake Aldred.

The Safe Harbor fishway began operation on 5 May, with operations ending on 9 June. A malfunction of motor-operated valve #1, (MOV1), resulted in the loss of approximately twelve hours of fishway operation from 10 May to 14 May. To limit the amount of lost fishing time, the fishway was operated manually until repairs were completed on 14 May. Lift operations ended due to the dwindling fish catch and rising water temperatures; indications that the migration run was ending.

Throughout the 2009 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 diskette 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 2009 by the Safe Harbor fishway is presented in Table 1. A total of 194,620 fish of 17 species and 2 hybrids passed upstream into Lake Clarke. Gizzard shad (174,233) was the dominant species passed and comprised nearly 90% of the catch. Some 7,994 American shad were passed upstream through the fishway and comprised 4% of the catch. Other predominant fishes passed included walleye (5,377), quillback (2,421), and channel catfish (2,068). Peak passage occurred on 17 May, when 11,032 fish, (nearly 94% gizzard shad), were passed.

3.2 American Shad Passage

The Safe Harbor fishway passed 7,994 American shad in 2009 during 36 days of operation (Table 1). This year's operating season was nine days shorter than the 2008 season, although passage operations were more successful in 2009. Safe Harbor managed to pass about 73% of the American shad passed at Holtwood Dam and 27% of the American shad passed by Conowingo Dam, (Table 4). Peak shad passage occurred on 5 May, (first day of operation), when 777 American shad were captured and passed during 7.5 hours of operation.

American shad were passed at water temperatures of 60.4°F to 75.0°F and river flows of 24,800 to 63,300 cfs (Table 2 and Figures 1 and 2). Water temperature was relatively stable this season as compared to 2008, and may be partly responsible for the improved American shad passage in 2009.

The number of American shad observed passing through the trough by hour is shown in Table 3. With the season's shad catch broken down based on hours of observation, passage rates were consistent from 1100 hrs to 1659 hrs. Passage sharply declined after 1700 hrs. The peak passage hour for American shad during the entire season was observed between 1200-1259 hrs, with a total of 966 American shad passed. The highest hourly passage (176) occurred between 1200 and 1259 hr on 5 May.

During the 2009 season, the Safe Harbor fishway passed one MD DNR tagged American shad, (2009 orange floy tag), 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 2009.

4.0 SUMMARY

The 2009 Safe Harbor fishway operating season was conducted with minimal disruptions to operations due to mechanical problems. The malfunction and repair of MOV1 resulted in the loss of about 12 hours of fishway operation from 10 to 14 May, but did not prevent the lift from operating on a daily basis. Manual operation of the fishway occurred while work crews repaired MOV1.

A total of 7,994 American shad were passed into Lake Clarke, or 73% of the American shad that were passed into Lake Aldred by the Holtwood fishway (Table 4). More than 90% of the total American shad passed at Safe Harbor occurred prior to 30 May, shortly after Holtwood passed 90% of their American shad season total. Future operations of the fishway will build on the past thirteen 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 by the Safe Harbor fishway in 2009.**

<i>Date:</i>	<i>5-May</i>	<i>6-May</i>	<i>7-May</i>	<i>8-May</i>	<i>9-May</i>	<i>10-May</i>	<i>11-May</i>	<i>12-May</i>	<i>13-May</i>	<i>14-May</i>	<i>15-May</i>
<i>Hours of Operation:</i>	7.5	10.2	9.5	10.4	10.5	5.3	6.4	4.8	8.5	9.8	9.8
<i>Viewing Start Time:</i>	11:15	8:10	8:15	8:00	8:00	8:00	11:00	13:40	8:00	8:50	8:00
<i>Viewing End Time:</i>	18:45	18:20	17:45	18:25	18:30	13:20	17:25	18:30	16:30	18:35	17:50
<i>Number of Lifts:</i>	9	13	12	14	14	7	9	7	8	11	14
<i>Water Temperature (°F):</i>	63	61	64.8	60.4	62.4	64.6	64.6	63.1	63.9	63	63
American Shad	777	500	323	346	444	147	162	117	40	241	195
Gizzard shad	6,290	5,615	5,460	7,635	9,512	3,200	4,080	5,025	3,850	5,416	9,520
Hybrid striped bass	0	0	0	0	0	0	0	0	0	0	0
Sea lamprey	0	1	0	1	0	0	0	1	0	1	0
Brown trout	0	1	0	0	0	0	0	1	0	0	0
Muskellunge	0	0	0	1	2	1	0	0	0	1	0
Tiger muskellunge	0	1	1	0	0	0	0	0	0	0	0
Carp	0	5	11	80	3	3	2	1	8	17	2
Quillback	93	77	31	108	247	62	15	0	0	16	27
Shorthead redhorse	24	92	37	175	163	72	11	0	7	55	54
Channel catfish	18	10	63	108	38	16	45	0	2	1	6
Flathead catfish	0	0	0	0	0	0	0	0	0	0	0
Rock bass	17	5	4	1	0	1	7	1	0	4	9
Bluegill	18	4	1	2	2	1	2	4	0	6	17
Smallmouth bass	86	80	55	30	105	24	33	25	22	26	21
Largemouth bass	0	0	0	0	0	0	1	1	0	0	0
White Crappie	0	0	0	0	1	0	0	0	0	0	1
Black Crappie	0	0	0	0	0	0	0	0	0	0	0
Walleye	42	44	18	25	133	103	68	89	13	105	363
Daily Total	7,365	6,435	6,004	8,512	10,650	3,630	4,426	5,265	3,942	5,889	10,215

Table 1**Continued.**

<i>Date:</i>	<i>16-May</i>	<i>17-May</i>	<i>18-May</i>	<i>19-May</i>	<i>20-May</i>	<i>21-May</i>	<i>22-May</i>	<i>23-May</i>	<i>24-May</i>	<i>25-May</i>	<i>26-May</i>
<i>Hours of Operation:</i>	10.8	10.0	10.6	11.1	10.6	9.5	10.2	9.7	9.0	10.1	9.8
<i>Viewing Start Time:</i>	8:00	8:00	8:00	7:30	8:00	8:00	7:40	8:00	8:00	7:30	8:00
<i>Viewing End Time:</i>	18:50	18:00	18:35	18:35	18:33	17:30	17:50	17:40	17:00	17:35	17:50
<i>Number of Lifts:</i>	16	13	15	13	11	10	11	10	13	14	13
<i>Water Temperature (°F):</i>	66.2	68	70	65	66	66.6	67	67	69.6	73	75
American Shad	194	402	249	287	389	155	185	100	249	557	504
Gizzard shad	8,196	10,340	9,594	9,569	6,325	3,355	6,588	4,985	8,325	7,090	6,245
Hybrid striped bass	0	0	0	0	0	0	0	0	0	0	0
Sea lamprey	0	0	0	0	1	0	1	0	2	0	0
Brown trout	0	0	0	1	0	0	0	0	1	1	0
Muskellunge	0	0	0	0	1	0	0	0	0	0	0
Tiger muskellunge	0	0	0	0	0	0	0	0	0	0	0
Carp	14	3	67	1	2	5	21	6	17	21	18
Quillback	324	50	155	3	0	1	7	0	308	265	67
Shorthead redhorse	105	3	20	4	0	2	4	0	2	17	5
Channel catfish	55	23	45	39	72	30	34	21	43	44	172
Flathead catfish	0	1	0	1	0	0	0	0	0	0	0
Rock bass	19	4	5	7	12	1	5	9	5	3	2
Bluegill	12	7	4	13	8	7	9	16	36	18	8
Smallmouth bass	50	24	63	5	8	6	4	5	1	3	0
Largemouth bass	1	1	0	0	0	1	1	2	0	0	1
White Crappie	0	0	1	0	0	0	0	0	0	0	0
Black Crappie	0	0	0	0	0	0	0	0	1	0	0
Walleye	762	174	811	45	109	91	195	437	354	242	212
Daily Total	9,732	11,032	11,014	9,975	6,927	3,654	7,054	5,581	9,344	8,261	7,234

Table 1

Continued.

<i>Date:</i>	27-May	28-May	29-May	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	6-Jun
<i>Hours of Operation:</i>	10.3	10.0	7.1	9.7	9.5	9.4	9.0	9.1	9.0	8.9	8.8
<i>Viewing Start Time:</i>	8:00	8:00	10:25	7:40	7:30	7:30	8:00	8:00	8:00	8:00	8:00
<i>Viewing End Time:</i>	18:15	18:00	17:30	17:20	17:00	16:55	17:00	17:08	17:00	16:56	16:50
<i>Number of Lifts:</i>	11	9	10	12	9	9	9	9	8	9	9
<i>Water Temperature (°F):</i>	72.9	72.5	72	71.5	71	66	67.8	69	69.4	71.4	71.1
American Shad	312	182	313	283	11	63	47	37	27	4	9
Gizzard shad	5,475	1,299	3,135	6,194	4,715	1,253	395	552	667	78	708
Hybrid striped bass	0	0	0	0	0	0	0	0	0	0	0
Sea lamprey	1	0	0	0	0	0	0	0	0	0	0
Brown trout	0	0	0	0	0	1	0	0	0	0	0
Muskellunge	0	0	0	0	1	0	0	0	0	0	0
Tiger muskellunge	0	0	0	0	0	0	0	0	0	0	0
Carp	205	0	5	2	0	5	2	7	9	3	0
Quillback	420	61	4	13	1	7	3	17	9	5	0
Shorthead redhorse	5	3	0	0	0	0	0	0	0	0	0
Channel catfish	290	53	61	236	40	54	23	26	126	103	6
Flathead catfish	0	0	0	0	0	0	0	0	0	0	0
Rock bass	5	0	1	1	0	1	0	2	1	0	0
Bluegill	5	13	8	5	0	1	1	1	1	1	0
Smallmouth bass	1	0	1	1	0	0	0	3	3	1	0
Largemouth bass	0	1	1	0	0	0	0	1	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	295	66	61	33	0	9	20	27	65	57	15
Daily Total	7,014	1,678	3,590	6,768	4,768	1,394	491	673	908	252	738

Table 1

Continued.

<i>Date:</i>	7-Jun	8-Jun	9-Jun	<i>Season Total</i>
<i>Hours of Operation:</i>	10.0	8.8	9.2	335.2
<i>Viewing Start Time:</i>	8:00	8:00	7:40	
<i>Viewing End Time:</i>	18:00	16:50	16:50	332.9 hours of viewing
<i>Number of Lifts:</i>	10	9	9	389
<i>Water Temperature (°F):</i>	71.1	67	70	
American Shad	62	62	19	7,994
Gizzard shad	1,655	1,470	422	174,233
Hybrid striped bass	1	0	0	1
Sea lamprey	0	0	0	9
Brown trout	0	0	0	6
Muskellunge	1	0	0	8
Tiger muskellunge	0	0	0	2
Carp	0	4	10	559
Quillback	0	5	20	2,421
Shorthead redhorse	0	0	2	862
Channel catfish	7	19	139	2,068
Flathead catfish	0	0	0	2
Rock bass	0	0	1	133
Bluegill	1	1	5	238
Smallmouth bass	1	0	0	687
Largemouth bass	2	1	1	16
White Crappie	0	0	0	3
Black Crappie	0	0	0	1
Walleye	48	69	177	5,377
Daily Total	1,778	1,631	796	194,620

Table 2

Summary of daily average river flow and water temperature as measured at Holtwood Dam, turbidity (secchi), unit operation, entrance gates utilized, attraction flow, and project water elevations during operation of the Safe Harbor fish passage facility in 2009.

Date	River Flow¹ (mcfs)	Water Temp (°F)	Secchi (in)	Maximum Units in Operation	Units Generated	Entrance Gates Utilized	Attraction Flow (cfs)	Tailrace Elevation (ft)	Forebay Elevation (ft)
5-May	37.4	63.0	20	5	3 to 5, 7, 8	A & C	500	172.1	226.8
6-May	46.7	61.0	20	Data	Not Recorded	A & C	500	172.3	226.4
7-May	62.6	64.8	18-16	10	1 to 5, 7 to 11	A & C	500	174.4	226.6
8-May	52.4	60.4	20-12	10	1 to 5, 7 to 11	A & C	500	173.8	226.7
9-May	48.5	62.4	20	7	3 to 5, 7 to 10	A & C	500	172.7	226.0
10-May	44.3	64.6	20-12	7	3 to 5, 7 to 10	A & C	500	173.2	226.7
11-May	42.3	64.6	24	8	1 to 4, 7 to 10	A & C	500	172.8	226.4
12-May	40.9	63.1	24	9	1 to 4, 7 to 11	A & C	500	172.0	226.2
13-May	35.3	63.9	20	8	1 to 4, 7 to 9, 11	A & C	500	171.0	226.9
14-May	34.4	63.0	24	6	1 to 4, 6, 7	A & C	500	171.1	226.5
15-May	35.6	63.0	22-16	6	1 to 4, 7, 8	A & C	500	171.7	226.4
16-May	35.6	66.2	22	6	1, 3, 4, 6 to 8	A & C	500	170.7	226.0
17-May	37.9	70.0	20	5	1, 3, 4, 6, 7	A & C	500	170.8	226.5
18-May	43.2	68.0	22	9	1 to 4, 6 to 10	A & C	500	173.5	226.0
19-May	54.8	65.0	24	6	1 to 4, 6, 7	A & C	500	173.9	225.5
20-May	54.4	66.0	24	9	1 to 4, 6 to 10	A & C	500	173.5	225.5
21-May	47.5	66.6	24-20	9	1 to 4, 6 to 10	A & C	500	173.0	226.3
22-May	39.9	67.0	24	6	1 to 4, 6, 7	A & C	500	173.0	226.3
23-May	34.2	67.0	24	8	1, 3, 4, 6 to 10	A & C	500	173.7	226.9
24-May	30.3	69.6	20-18	6	1, 3, 4, 6 to 8	A & C	500	171.2	227.0
25-May	28.8	73.0	24	9	1 to 4, 6 to 9, 11	A & C	500	169.5	226.5
26-May	25.9	75.0	22	6	1 to 4, 6, 7	A & C	500	170.3	226.7
27-May	25.2	72.9	22	3	1, 3, 6	A & C	500	169.3	226.7
28-May	24.8	72.5	18	5	1, 3, 4, 6, 7	A & C	500	170.8	226.7
29-May	41.8	72.0	20	7	1, 3, 4, 6 to 9	A & C	500	173.1	226.3
30-May	63.3	71.5	12	8	3, 4, 6 to 11	A & C	500	174.4	226.2
31-May	54.9	71.0	8	7	3, 4, 6 to 10	A & C	500	173.9	226.2
1-Jun	48.7	66.0	12	7	2 to 4, 6 to 8, 10	A & C	500	173.7	226.6
2-Jun	42.4	67.8	16	8	2 to 4, 6 to 10	A & C	500	173.4	226.6
3-Jun	38.4	69.0	24	6	2 to 4, 6 to 8	A & C	500	172.4	226.9
4-Jun	37.7	69.4	20	6	2 to 4, 6 to 8	A & C	500	172.2	226.0
5-Jun	35.8	71.4	20	7	2 to 4, 6 to 9	A & C	500	172.1	226.9
6-Jun	37.9	71.1	18	6	3, 4, 6 to 9	A & C	500	172.0	226.9
7-Jun	32.0	71.1	22	6	3, 4, 6 to 9	A & C	500	172.0	226.6
8-Jun	28.0	67.0	20	Data	Not Recorded	A & C	500	170.7	226.7
9-Jun	26.2	70.0	20	Data	Not Recorded	A & C	500	170.3	226.7

¹ River flow and temperature measured at Holtwood Dam.

Table 3

Hourly summary of American shad passage at the Safe Harbor fish passage facility in 2009.

<i>Date:</i>	<i>5-May</i>	<i>6-May</i>	<i>7-May</i>	<i>8-May</i>	<i>9-May</i>	<i>10-May</i>	<i>11-May</i>	<i>12-May</i>	<i>13-May</i>	<i>14-May</i>	<i>15-May</i>	<i>16-May</i>
Observation Time-Start:	<i>11:15</i>	<i>8:10</i>	<i>8:15</i>	<i>8:00</i>	<i>8:00</i>	<i>8:00</i>	<i>11:00</i>	<i>13:40</i>	<i>8:00</i>	<i>8:50</i>	<i>8:00</i>	<i>8:00</i>
Observation Time-End:	<i>18:45</i>	<i>18:20</i>	<i>17:45</i>	<i>18:25</i>	<i>18:30</i>	<i>13:20</i>	<i>17:25</i>	<i>18:30</i>	<i>16:30</i>	<i>18:35</i>	<i>17:50</i>	<i>18:50</i>
Military Time (hrs)												
0700 to 0759	--	--	--	--	--	--	--	--	--	--	--	--
0800 to 0859	--	46	44	28	13	17	--	--	0	1	9	9
0900 to 0959	--	38	43	25	13	35	--	--	0	1	15	9
1000 to 1059	--	16	34	68	37	27	--	--	9	14	16	3
1100 to 1159	105	19	29	19	31	32	11	--	9	35	20	31
1200 to 1259	176	27	30	21	36	19	12	--	14	42	19	52
1300 to 1359	149	56	25	54	59	17	6	23	8	20	17	10
1400 to 1459	90	40	27	41	82	--	20	21	--	18	37	33
1500 to 1559	100	75	42	26	59	--	26	31	--	33	16	17
1600 to 1659	73	66	23	48	56	--	54	29	--	37	27	17
1700 to 1759	55	73	26	10	44	--	33	11	--	26	19	7
1800 to 1859	29	44	--	6	14	--	--	2	--	14	--	6
1900 to 1959												
Total	777	500	323	346	444	147	162	117	40	241	195	194

<i>Date:</i>	<i>17-May</i>	<i>18-May</i>	<i>19-May</i>	<i>20-May</i>	<i>21-May</i>	<i>22-May</i>	<i>23-May</i>	<i>24-May</i>	<i>25-May</i>	<i>26-May</i>	<i>27-May</i>	<i>28-May</i>
Observation Time-Start:	<i>8:00</i>	<i>8:00</i>	<i>7:30</i>	<i>8:00</i>	<i>8:00</i>	<i>7:40</i>	<i>8:00</i>	<i>8:00</i>	<i>7:30</i>	<i>8:00</i>	<i>8:00</i>	<i>8:00</i>
Observation Time-End:	<i>18:00</i>	<i>18:35</i>	<i>18:35</i>	<i>18:33</i>	<i>17:30</i>	<i>17:50</i>	<i>17:40</i>	<i>17:00</i>	<i>17:35</i>	<i>17:50</i>	<i>18:15</i>	<i>18:00</i>
Military Time (hrs)												
0700 to 0759	--	--	1	--	--	2	--	--	5	--	--	--
0800 to 0859	18	11	15	49	34	14	27	5	62	44	48	16
0900 to 0959	14	9	13	11	6	9	2	41	102	101	58	4
1000 to 1059	58	29	15	9	4	23	13	46	94	72	31	17
1100 to 1159	43	14	7	15	17	21	17	43	38	112	44	12
1200 to 1259	81	26	15	19	7	26	8	54	99	86	18	2
1300 to 1359	50	48	35	34	17	11	7	24	62	39	30	18
1400 to 1459	39	31	44	13	20	16	7	22	33	16	16	43
1500 to 1559	32	31	68	36	11	12	7	10	28	10	16	37
1600 to 1659	42	11	41	93	23	21	9	4	21	15	17	25
1700 to 1759	25	20	25	78	16	30	3	--	13	9	20	8
1800 to 1859	--	19	8	32	--	--	--	--	--	--	14	--
1900 to 1959												
Total	402	249	287	389	155	185	100	249	557	504	312	182

Table 3

Continued.

<i>Date:</i>	29-May	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	6-Jun	7-Jun	8-Jun	9-Jun
Observation Time-Start:	10:25	7:40	7:30	7:30	8:00	8:00	8:00	8:00	8:00	8:00	8:00	7:40
Observation Time-End:	17:30	17:20	17:00	16:55	17:00	17:08	17:00	16:56	16:50	18:00	16:50	16:50
Military Time (hrs)												
0700 to 0759	--	1	1	3	--	--	--	--	--	--	--	2
0800 to 0859	--	42	0	8	4	3	4	0	4	1	5	8
0900 to 0959	--	23	3	3	11	0	10	1	0	7	4	2
1000 to 1059	17	49	0	2	3	2	1	0	1	1	16	4
1100 to 1159	52	39	0	2	1	0	3	3	1	3	15	1
1200 to 1259	27	25	0	6	0	2	0	0	0	10	6	1
1300 to 1359	33	44	2	8	4	3	2	0	0	15	1	1
1400 to 1459	41	25	0	1	2	5	2	0	1	11	6	0
1500 to 1559	64	27	3	16	7	12	2	0	0	8	6	0
1600 to 1659	55	5	2	14	15	3	3	0	2	4	3	0
1700 to 1759	24	3	--	--	--	7	--	--	--	2	--	--
1800 to 1859												
1900 to 1959												
Total	313	283	11	63	47	37	27	4	9	62	62	19

<i>Date:</i>	<i>Season</i>	<i>Season</i>
Observation Time-Start:	Season	Season
Observation Time-End:	Total	Total
Military Time (hrs)		
0700 to 0759		15
0800 to 0859		589
0900 to 0959		613
1000 to 1059		731
1100 to 1159		844
1200 to 1259		966
1300 to 1359		932
1400 to 1459		803
1500 to 1559		868
1600 to 1659		858
1700 to 1759		587
1800 to 1859		188
1900 to 1959		0
Total		7,994

Table 4**Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2009.**

	Conowingo	Holtwood		Safe Harbor		York Haven	
	East	Number	% of C.E.L.	Number	% of Holt.	Number	% of S.H.
1997	90,971	28,063	30.8%	20,828	74.2%	-	-
1998	39,904	8,235	20.6%	6,054	73.5%	-	-
1999	69,712	34,702	49.8%	34,150	98.4%	-	-
2000	153,546	29,421	19.2%	21,079	71.6%	4,687	22.2%
2001	193,574	109,976	56.8%	89,816	81.7%	16,200	18.0%
2002	108,001	17,522	16.2%	11,705	66.8%	1,555	13.3%
2003	125,135	25,254	20.2%	16,646	65.9%	2,536	15.2%
2004	109,360	3,428	3.1%	2,109	61.5%	219	10.4%
2005	68,926	34,189	49.6%	25,425	74.4%	1,772	7.0%
2006	56,899	35,968	63.2%	24,929	69.3%	1,913	7.7%
2007	25,464	10,338	40.6%	7,215	69.8%	192	2.7%
2008	19,914	2,795	14.0%	1,252	44.8%	21	1.7%
2009	29,272	10,896	37.2%	7,994	73.4%	402	5.0%

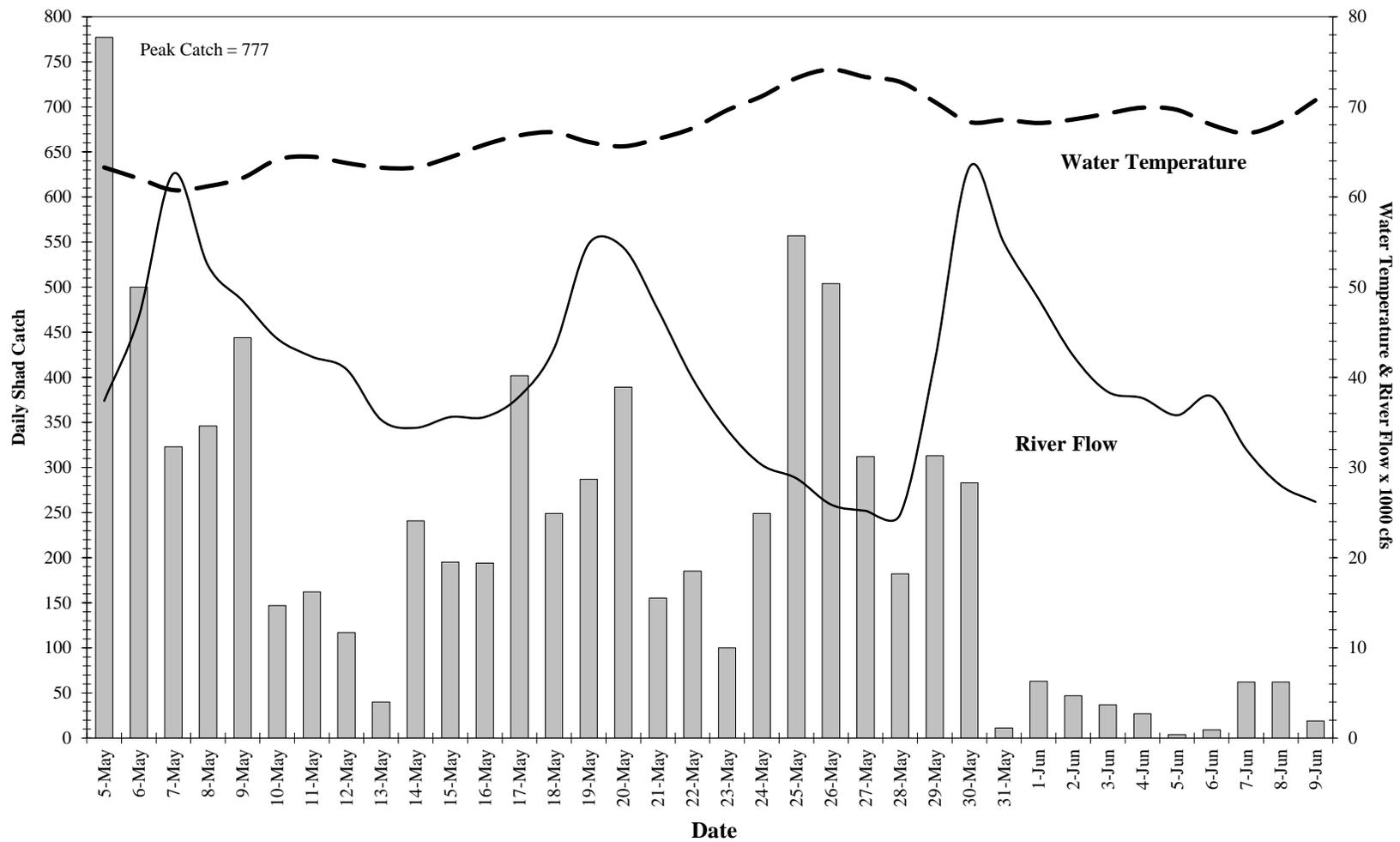


Fig. 1

A plot of river flow (x 1000 cfs) and water temperature (°F) as measured at Holtwood Dam, in relationship to the daily American shad catch at the Safe Harbor Fish Passage Facility, spring 2009.

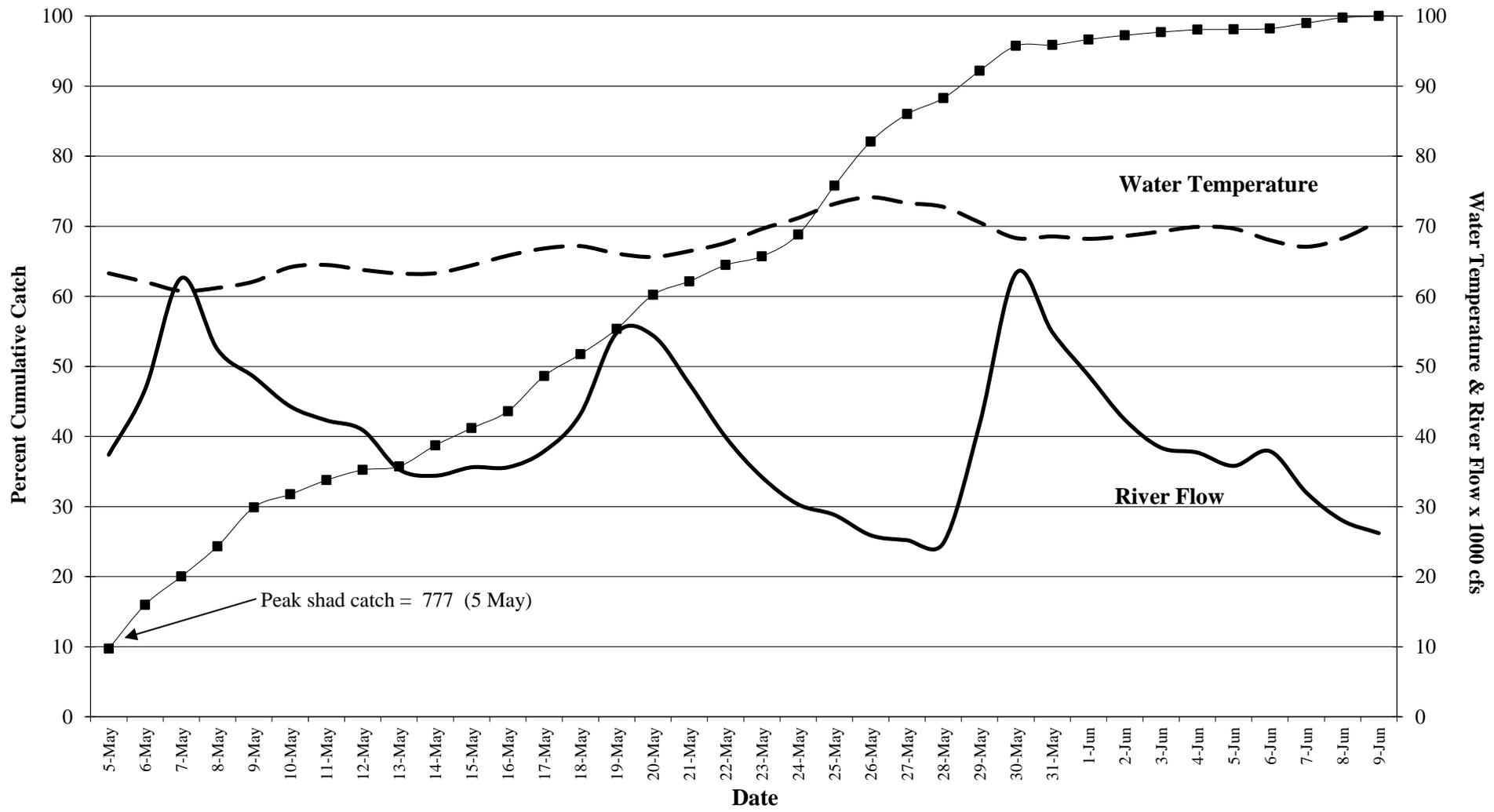


Fig. 2

A plot of river flow (x 1000 cfs) and water temperature (°F) as measured at Holtwood Dam, in relationship to the percent cumulative American shad catch at the Safe Harbor Fish Passage Facility, spring 2009.