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Summary of Operations at the Safe Harbor Fish Passage Facility Spring 2019

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Executive Summary

Operation of the Safe Harbor Fish Lift began 3 May, 2019; 2 days after Holtwood passed its first American Shad into Lake Aldred. The average water temperature on 3 May was 59.3°F and the river flow was 52,600 cfs. The first American Shad was passed at Safe Harbor on the initial day of operation, (3 May). Daily fish lift operations were conducted from 3 May through 13 May, with operations suspended from 14 May through 18 May due to high river flows. Daily operations resumed on 19 May and continued through season end on 6 June. Operation at the Safe Harbor Fish Lift ended on 6 June (with concurrence by the Resource Agencies) due to the dwindling fish catch and water temperatures at or above 70° F; indications that the migration run was ending. Due to the 5-day high river flow event in May, and the late arrival of American Shad to Holtwood (May 1), the Safe Harbor fish lift was operated on 30 days in 2019 (31 days in 2018; 46 days in 2017). The 2019 fish passage season marks the twenty-third season of volitional fish passage at the Safe Harbor Fish Lift.

The Safe Harbor Fish Lift passed 58,091 fish of 16 species into Lake Clarke. Gizzard shad (31,147), channel catfish (13,012), and quillback (12,415) dominated the catch, and comprised 97.3% of the total fish collected and passed. Gizzard shad was the dominant species passed and comprised 53.6% of the catch.

A total of 316 American Shad was passed during the 2019 season at Safe Harbor comprising 30 days of operation. The highest daily passage of American Shad occurred on 6 May, when 195 American Shad were captured and passed upstream. The passage of American Shad during the entire season was generally low during all hours of operation, with the highest hour of passage occurring from 0800 hours to 0859 hours (67). The 4-hour period between 0800 and 1159 hours accounted for 54.4% of the total season passage.

Fishway operations were conducted at water temperatures ranging from 59.3°F to 75.3°F and river flows of 40,700 to 108,000 cfs. River flows were generally higher during the entire 2019 fish passage season, resulting in the suspension of fish passage operations from 14 through 18 May due to river flows exceeding 100,000 cfs. Water temperature was generally at or above 70° F from 26 May through season end on 6 June.

On 24 of the 30 days of operation, water clarity was good (≥ 18 inches of visibility at the viewing window), allowing the viewing technicians to accurately identify American Shad and other fish species. Although viewing conditions were adequate in 2019, no American Shad with Maryland DNR floy tags were observed at the Safe Harbor Fishway.

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

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

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

1.0 Introduction

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

Objectives for 2019 operation were to (1) monitor passage of migratory and resident fishes through the fishway; (2) assess fishway effectiveness; and (3) continue to assess any impacts of fish passage through the trough when the air bubbler system is in use during fish passage operations.

2.0 Safe Harbor Operation

2.1 Project Operation

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

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

2.2 Fishway Design and Operation

2.2.1 Fishway Design

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

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

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

Conceptual design guidelines for fishway operation included several entrance combinations. They are (1) entrance A, B, and C; (2) entrance B and C; (3) entrance A and C, and (4) entrance A, B, and C individually. Operation during the 2019 season utilized a combination of entrances A and C.

2.2.2 Fishway Operation

Safe Harbor fishway operation generally commences soon after passage of approximately 500 American Shad via the Holtwood fishway. However, in 2019, operations commenced on 3 May, 2 days after Holtwood passed its first American Shad into Lake Aldred.

The Safe Harbor fishway began operation on 3 May, with operations ending on 6 June. Lift operations ended due to the dwindling fish catch and rising water temperatures; indications that the adult American Shad migration season was ending.

Throughout the 2019 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. Due to river flows at or above 100,000 cfs, fish lift operations were suspended from 14 through 18 May which may have impacted the passage of American Shad at Safe Harbor this season. No mechanical issues resulting in suspension of fish lift operations occurred during the 2019 fish passage season.

2.3 Fish Counts

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

A 1,500 watt halogen lamp mounted above the viewing window and three adjustable 500 watt underwater lights (two at mid-depth on either side of the window and one on the bottom) gave the biologist and/or technician a degree of control over lighting conditions at the window. Overhead and underwater light intensity was adjusted daily, based on the constantly changing ambient light conditions. In addition, a screen capable of adjusting the channel width at the counting window

from 18 in to 36 in (and a range of intermediate widths) was adjusted as viewing conditions and fish passage dictated. For the entire 2019 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 2019 by the Safe Harbor fishway is presented in Table 1. A total of 58,091 fish of 16 species passed upstream into Lake Clarke. Gizzard shad (31,147) was the dominant species passed and comprised 53.6% of the catch. Some 316 American Shad were passed upstream through the fishway and comprised < 1% of the catch. Other predominant fishes passed included channel catfish (13,012) and quillback (12,415). The highest fish passage day occurred on 27 May, when 6,379 fish, (75.2% gizzard shad and 17.5% channel catfish), were passed.

3.2 American Shad Passage

The Safe Harbor fishway passed 316 American Shad in 2019 during 30 days of operation (Tables 1 and 2).This year's passage of American Shad (316) is the second lowest number of American Shad passed since 1997 (Table 3). Safe Harbor managed to pass 55.4% of the American Shad passed at Holtwood Dam and 6.6% of the American Shad passed by Conowingo Dam, (Table 3). Peak shad passage occurred on 6 May, when 195 American Shad were captured and passed during 8 hours of viewing operation. American Shad passage from 3 through 13 May, (306), accounted for all but 10 of the American Shad passed at Safe Harbor in 2019.

American Shad were passed at water temperatures of 59.3°F to 73.8°F and river flows of 43,200 to 108,000 cfs (Table 2 and Figures 1and 2). The river flow average during the 30-day fish lift operating period in 2019 was approximately 69,300 cfs; higher than observed in 2018 (approximately 46,200 cfs), with a major high flow event (river flow > 100,000 cfs) occurring from 14 through 18 May resulting in spillage and suspension of fish passage operations. Water temperature did not spike in early May as has been observed in some years with temperatures near or ≥ 70° F recorded from 26 May to season end on 6 June.

The number of American Shad observed passing through the trough by hour is shown in Table 4. With the season's shad catch broken down based on hours of observation, passage rates were generally low throughout the entire day. The highest hourly passage values for American Shad during the entire season were observed between 0800 and 0859 (67) and 1400 to 1459 hrs (47), accounting for 36% of the total season passage. The highest number of American Shad passed in one hour (59) occurred between 0800 to 0859 hrs on 6 May.

During the 2019 season, the Safe Harbor fishway did not pass any American Shad with MD DNR floy tags that had been passed by downstream fish lift facilities.

3.3 Gizzard Shad Passage and Other Alosids

The Safe Harbor fish lift collected and passed 31,147 Gizzard Shad in 2019 (Tables 1 and 5), which accounted for 53.6% of the total fish collected and passed. The total number of Gizzard Shad observed in 2019 is much lower than that observed in 2018 (113,849); due possibly to the higher daily average river flows experienced this season. Gizzard Shad passage at Safe Harbor never exceeded 5,000 fish on any day, with the highest number (4,798) passed on 27 May (Table 5). Table 5 lists the daily hourly passage of Gizzard Shad at Safe Harbor during the 2019 fish passage season.

Passage of other Alosids, (alewife, blueback herring, and hickory shad), at the Safe Harbor fishway was not observed in 2019.

3.4 Evaluation of Air Bubbler System

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

During the 2019 fish passage season, the fish counting technicians were instructed to record daily observations of fish behavior/passage whether the air bubbler system was on or off. At no time during fish passage operations did the technicians observe fish "stacking up" at the trough exit area or large numbers of fish swimming downstream past the window after having passed the viewing window earlier in the day.

Since 1997 (initial year of operation at Safe Harbor), fish counting technicians have observed on a limited basis an initial unwillingness of fish to quickly swim past the viewing window. Upon inspection of the facility by station personnel, the cause has been a build-up of debris on the retractable screens at the viewing windows. Once the screens are cleaned of debris, fish passage returns to normal. In 2019, the retractable screen for the public viewing room was positioned flat against the far wall so there was only one area that the fish were limited to a width of 18 inches when swimming past the viewing windows. It appears that this simple modification, as well as from observations made during previous fish passage seasons, that the air bubbler system located at the fish trough exit does prevent large amounts of debris from entering the fish trough when present at the trough exit, thus aiding in the maintenance of normal fish passage conditions for all fish species that enter and pass through the Safe Harbor fish lift.

4.0 Summary

In 2019, the Safe Harbor fishway passage season was conducted without any disruptions to operations due to mechanical problems.

A total of 316 American Shad were passed into Lake Clarke, or 55.4% of the American Shad that were passed into Lake Aldred by the Holtwood fishway (Table 3), similar to the passage percentage observed in 2014 (51.6%). All except 10 of the total American Shad passed at Safe Harbor occurred prior to 14 May (Table 2 and Figure 2), possibly due to the high river flow event that occurred from 14 through 18 May which appears to have significantly impacted American Shad passage at all of the

fish passage facilities on the lower Susquehanna River in 2019. Future operations of the fishway will build on the past twenty-three years of experience.

5.0 Recommendations

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

6.0 Literature Cited

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

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

Figures

Figure 1. A plot of river flow (USGS Marietta Gauge) and water temperature (°F), in relation to the daily American Shad catch at the Safe Harbor Fish Passage Facility, Spring 2019.

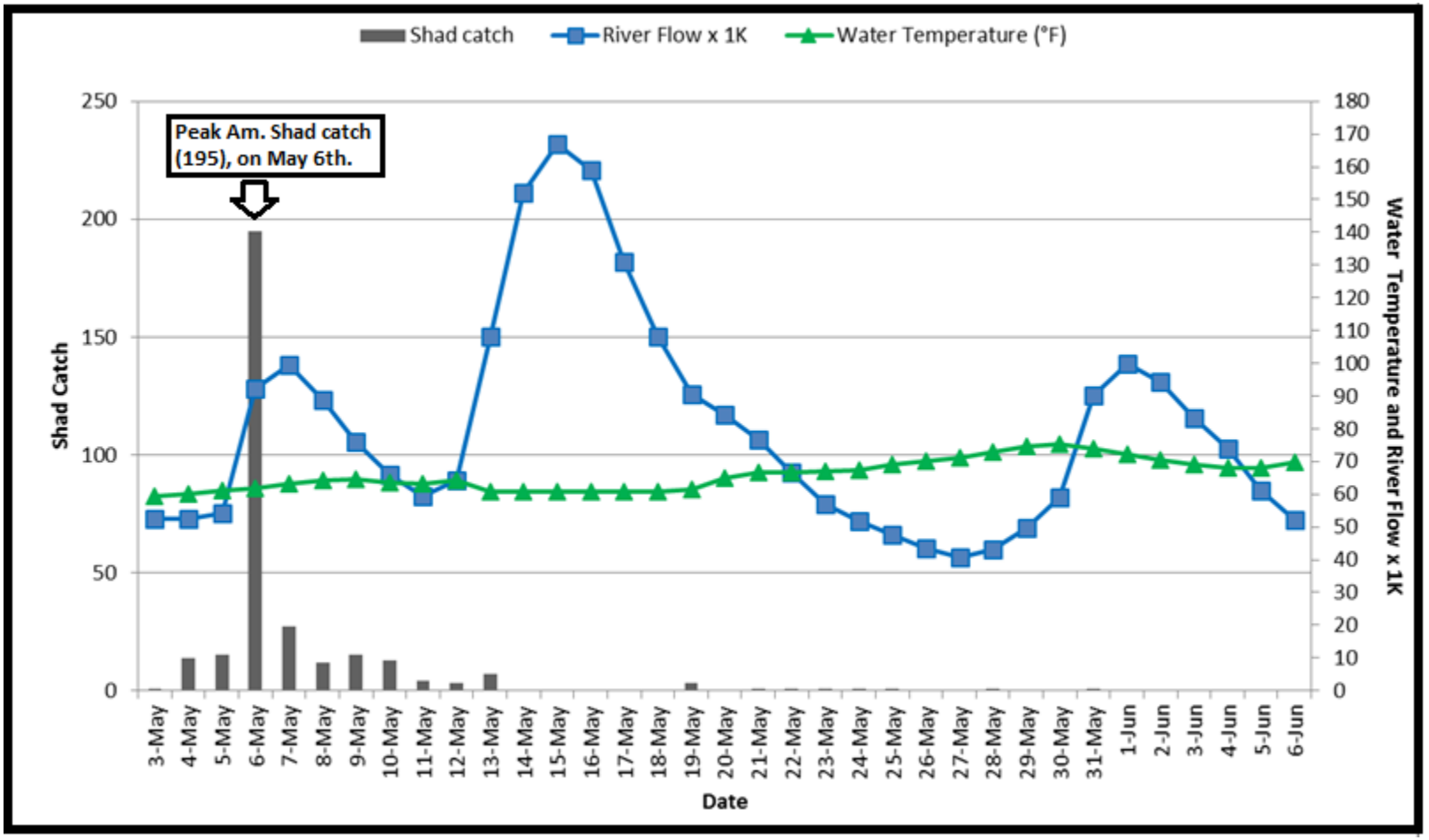
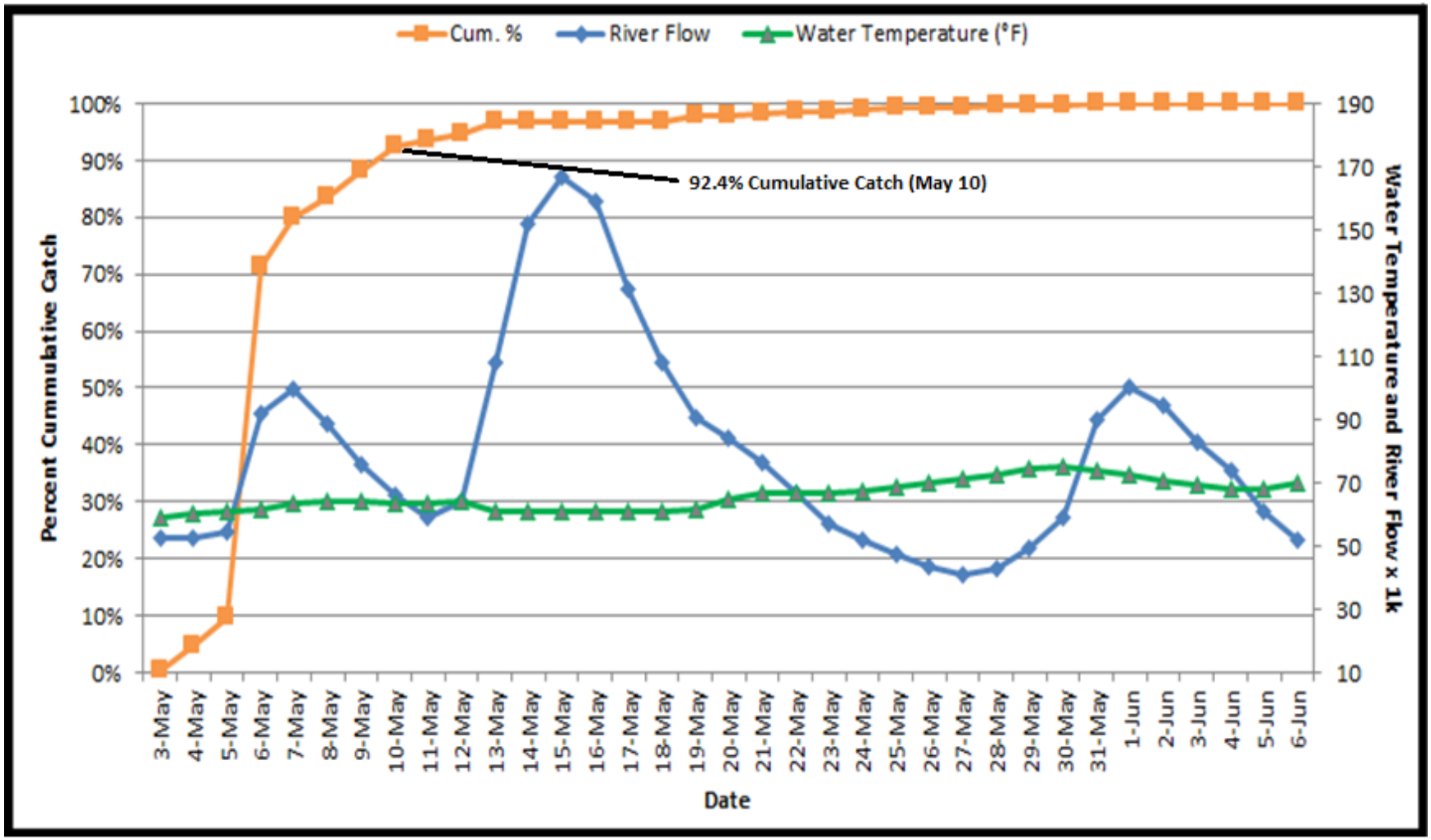


Figure 2. **A plot of river flow (USGS Marietta Gauge) and water temperature (°F), in relation to the percent cumulative American Shad catch at the Safe Harbor Fish Passage Facility, Spring 2019.**



Tables

Table 1.
Number and disposition of fish passed daily by the Safe Harbor fishway in 2019.

Date	5/3	5/4	5/5	5/6	5/7	5/8	5/9	5/10	5/11	5/12
Start Veiwing Time	12:50	7:30	7:35	8:00	8:00	7:30	7:30	8:30	7:15	8:00
End Viewing Time	17:15	17:20	16:00	16:00	16:25	16:30	17:20	18:00	17:15	17:15
Elapsed Viewing Time	4.4	9.8	8.4	8.0	8.4	9.0	9.8	9.5	10.0	9.3
Lifts Per Day	7	12	10	10	10	10	12	10	12	12
Water Temperature (F)	59.3	60.1	61	61.9	63.3	64.1	64.5	63.6	63.3	64.2
AMERICAN SHAD	1	14	15	195	27	12	15	13	4	3
GIZZARD SHAD	250	935	643	2,215	907	2,101	1,876	1,230	1,821	999
RAINBOW TROUT	0	0	0	0	0	0	0	0	0	0
MUSKELLUNGE	0	0	0	0	0	0	0	0	0	0
LONGNOSE GAR	0	0	0	0	0	0	0	0	0	0
CARP	7	21	17	4	6	18	10	9	37	6
QUILLBACK	2,271	1,355	618	11	0	21	72	351	726	363
S. REDHORSE	32	69	35	4	1	0	5	20	13	5
CHANNEL CATFISH	333	269	418	325	202	109	272	201	145	389
FLATHEAD CATFISH	0	0	0	0	0	1	0	0	0	1
PUMPKINSEED	0	0	0	0	0	0	0	0	0	0
BLUEGILL	0	0	0	0	0	0	0	0	1	0
SMALLMOUTH BASS	139	24	23	22	3	2	3	4	7	1
LARGEMOUTH BASS	0	0	0	0	0	0	0	1	0	0
YELLOW PERCH	0	0	0	1	0	0	0	0	0	0
WALLEYE	1	5	6	2	0	2	0	0	3	3
TOTALS	**3,034**	**2,692**	**1,775**	**2,779**	**1,146**	**2,266**	**2,253**	**1,829**	**2,757**	**1,770**

Table 1. (Continued)

Date	5/13	5/14	5/15	5/16	5/17	5/18	5/19	5/20	5/21	5/22
Start Veiwing Time	7:30						8:00	8:00	9:40	7:30
End Viewing Time	15:45	Did	Did	Did	Did	Did	16:05	16:30	17:15	17:00
Elapsed Viewing Time	8.3	Not	Not	Not	Not	Not	8.1	8.5	7.6	9.5
Lifts Per Day	10	Operate	Operate	Operate	Operate	Operate	10	10	11	14
Water Temperature (F)	60.7						61.3	64.9	66.6	66.6
AMERICAN SHAD	7						3	0	1	1
GIZZARD SHAD	95						598	662	818	737
RAINBOW TROUT	0						0	0	0	0
MUSKELLUNGE	1						0	1	0	0
LONGNOSE GAR	0						0	0	0	0
CARP	0						5	43	22	49
QUILLBACK	20						317	1,025	318	900
S. REDHORSE	0						4	7	4	10
CHANNEL CATFISH	31						152	440	443	702
FLATHEAD CATFISH	0						0	0	0	0
PUMPKINSEED	0						0	0	0	0
BLUEGILL	0						0	0	0	0
SMALLMOUTH BASS	0						11	19	11	4
LARGEMOUTH BASS	0						0	0	0	0
YELLOW PERCH	0						0	0	0	0
WALLEYE	0						0	0	0	0
TOTALS	**154**	**0**	**0**	**0**	**0**	**0**	**1,090**	**2,197**	**1,617**	**2,403**

Table 1. (Continued)

Date	5/23	5/24	5/25	5/26	5/27	5/28	5/29	5/30	5/31	6/1
Start Veiwing Time	7:20	8:00	7:30	8:00	7:30	8:00	7:30	8:00	9:10	8:00
End Viewing Time	17:00	17:15	16:00	16:00	15:55	16:00	17:15	17:10	17:15	17:15
Elapsed Viewing Time	9.7	9.3	8.5	8.0	8.4	8.0	9.8	9.2	8.1	9.3
Lifts Per Day	12	14	10	11	10	10	12	12	10	11
Water Temperature (F)	67	67.3	69	70	71	72.8	74.5	75.3	73.8	72.3
AMERICAN SHAD	1	1	1	0	0	1	0	0	1	0
GIZZARD SHAD	468	1,101	947	1,488	4,798	2,583	1,457	529	971	545
RAINBOW TROUT	0	0	0	0	0	0	0	0	0	1
MUSKELLUNGE	1	0	0	1	1	0	0	0	1	0
LONGNOSE GAR	0	0	0	0	0	0	1	0	0	0
CARP	53	15	16	8	6	41	66	32	12	3
QUILLBACK	610	315	734	862	433	422	366	291	6	0
S. REDHORSE	11	4	8	23	8	14	4	4	0	0
CHANNEL CATFISH	419	693	1,073	1,193	1,122	1,402	1,381	829	139	22
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	3	5
PUMPKINSEED	0	0	0	0	0	0	2	0	0	0
BLUEGILL	0	0	0	0	0	1	1	0	1	1
SMALLMOUTH BASS	6	7	11	4	5	4	2	3	1	0
LARGEMOUTH BASS	0	0	0	0	0	1	0	0	0	0
YELLOW PERCH	0	0	0	0	0	0	0	0	0	0
WALLEYE	2	3	4	4	6	6	9	4	0	0
TOTALS	**1,571**	**2,139**	**2,794**	**3,583**	**6,379**	**4,475**	**3,289**	**1,692**	**1,135**	**577**

Table 1. (Continued)

Date	6/2	6/3	6/4	6/5	6/6	**Season Total**
Start Veiwing Time	7:30	7:30	7:20	8:00	7:30	
End Viewing Time	15:50	16:30	15:50	15:40	14:00	
Elapsed Viewing Time	8.3	9.0	8.5	7.7	6.5	**257**
Lifts Per Day	10	9	9	11	9	**320**
Water Temperature (F)	70.6	69.2	68.2	68.1	69.7	
AMERICAN SHAD	0	0	0	0	0	**316**
GIZZARD SHAD	85	97	45	51	95	**31,147**
RAINBOW TROUT	0	0	0	0	0	**1**
MUSKELLUNGE	0	0	0	0	0	**6**
LONGNOSE GAR	0	0	0	0	0	**1**
CARP	2	0	0	1	1	**510**
QUILLBACK	0	0	0	0	8	**12,415**
S. REDHORSE	0	0	0	0	0	**285**
CHANNEL CATFISH	15	13	13	56	211	**13,012**
FLATHEAD CATFISH	0	0	0	0	0	**10**
PUMPKINSEED	0	0	0	0	0	**2**
BLUEGILL	0	0	0	0	1	**6**
SMALLMOUTH BASS	1	0	0	0	0	**317**
LARGEMOUTH BASS	0	0	0	0	0	**2**
YELLOW PERCH	0	0	0	0	0	**1**
WALLEYE	0	0	0	0	0	**60**
TOTALS	**103**	**110**	**58**	**108**	**316**	**58,091**

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 2019.**

Date	River Flow[1] (mcfs)	Water Temp (°F)	Secchi (in)	Maximum # of Units Operating	Entrance Gates Utilized	Attraction Flow (cfs)	Tailrace Elevation (ft)	Forebay Elevation (ft)	Daily No. of Am. Shad Passed
3-May	52,600	59.3	30	10	A/C	500	172.4	226.5	1
4-May	52,500	60.1	36	9	A/C	500	172.3	226.5	14
5-May	54,300	61	30	9	A/C	500	172.6	226.5	15
6-May	92,200	61.9	28	11	A/C	500	175.0	226.6	195
7-May	99,500	63.3	10-12	12	A/C	500	175.9	225.9	27
8-May	88,800	64.1	10-12	11	A/C	500	175.2	226.6	12
9-May	76,000	64.5	18	10	A/C	500	174.3	226.6	15
10-May	66,000	63.6	28	12	A/C	500	173.7	226.5	13
11-May	59,300	63.3	28	10	A/C	500	173.1	226.7	4
12-May	64,100	64.2	26	9	A/C	500	173.3	226.6	3
13-May	108,000	60.7	20	12	A/C	500	176.1	226.7	7
14-May	152,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	14-18 May	0
15-May	167,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	14-18 May	0
16-May	159,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	14-18 May	0
17-May	131,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	14-18 May	0
18-May	108,000	No	Operation	Due to	River Flows	≥ 100,000	cfs from	14-18 May	0
19-May	90,500	61.3	18	10	A/C	500	175.6	226.7	3
20-May	84,300	64.9	28	11	A/C	500	175.2	225.8	0
21-May	76,600	66.6	20	11	A/C	500	174.6	226.5	1
22-May	66,600	66.6	24	10	A/C	500	173.1	226.5	1
23-May	57,100	67	24	10	A/C	500	173.1	226.7	1
24-May	51,800	67.3	24	8	A/C	500	173.0	226.5	1
25-May	47,700	69	20	8	A/C	500	173.0	227.0	1
26-May	43,500	70	20	7	A/C	500	172.5	226.7	0
27-May	40,700	71	20	8	A/C	500	172.0	226.9	0
28-May	43,200	72.8	20	9	A/C	500	172.0	226.5	1
29-May	49,600	74.5	18	7	A/C	500	172.1	226.5	0
30-May	59,100	75.3	20	9	A/C	500	172.9	226.4	0
31-May	90,900	73.8	15-18	10	A/C	500	175.3	226.3	1
1-Jun	100,000	72.3	10-12	10	A/C	500	175.7	225.7	0
2-Jun	94,400	70.6	10	10	A/C	500	175.4	226.4	0
3-Jun	83,200	69.2	18	11	A/C	500	174.9	226.6	0
4-Jun	73,900	68.2	15	10	A/C	500	174.5	226.6	0
5-Jun	61,000	68.1	16	11	A/C	500	173.3	226.5	0
6-Jun	52,000	69.7	18	10	A/C	500	172.7	226.8	0

1 River flow measured at USGS Marietta Guage.

Table 3. Summary of American Shad passage counts and percent passage values at Susquehanna River dams, 1997-2019.

	Conowingo East	Holtwood*		Safe Harbor		York Haven	
		Number	% of C.E.L.	Number	% of Holt.	Number	% of S.H.
1997	90,971	28,063	30.8%	20,828	74.2%	-	-
1998	39,904	8,235	20.6%	6,054	73.5%	-	-
1999	69,712	34,702	49.8%	34,150	98.4%	-	-
2000	153,546	29,421	19.2%	21,079	71.6%	4,687	22.2%
2001	193,574	109,976	56.8%	89,816	81.7%	16,200	18.0%
2002	108,001	17,522	16.2%	11,705	66.8%	1,555	13.3%
2003	125,135	25,254	20.2%	16,646	65.9%	2,536	15.2%
2004	109,360	3,428	3.1%	2,109	61.5%	219	10.4%
2005	68,926	34,189	49.6%	25,425	74.4%	1,772	7.0%
2006	56,899	35,968	63.2%	24,929	69.3%	1,913	7.7%
2007	25,464	10,338	40.6%	7,215	69.8%	192	2.7%
2008	19,914	2,795	14.0%	1,252	44.8%	21	1.7%
2009	29,272	10,896	37.2%	7,994	73.4%	402	5.0%
2010	37,757	16,472	43.6%	12,706	77.14%	907	7.14%
2011	20,571	21	0.1%	8	38.1%	0	0.0%
2012	22,143	4,238	19.1%	3,089	72.9%	224	7.3%
2013	12,733	2,503	19.7%	1,927	77.0%	202	10.5%
2014	10,425	2,589	24.8%	1,336	51.6%	8	0.6%
2015	8,341	5,286	63.4%	3,896	73.7%	43	1.1%
2016	14,276	6,718	47.1%	4,242	63.1%	178	4.2%
2017	16,265	3,170	19.5%	2,007	63.3%	62	3.1%
2018	6,992	1,458	20.9%	661	45.3%	NA	NA
2019	**4,787**	**570**	**11.9%**	**316**	**55.4%**	**NA**	**NA**

*Am. Shad passed at Holtwood from May 1 to June 5.

Table 4. Hourly summary of daily American Shad passage at the Safe Harbor fish passage facility in 2019.

Date:	5/3	5/4	5/5	5/6	5/7	5/8	5/9	5/10	5/11	5/12	5/13	5/14
Observation Time-Start:	12:50	7:30	7:35	8:00	8:00	7:30	7:30	8:30	7:15	8:00	7:30	
Observation Time-End:	17:15	17:20	16:00	16:00	16:25	16:30	17:20	18:00	17:15	17:15	15:45	
Military Time (hrs)												
0600 to 0659												
0700 to 0759		1	0			0	3		3		0	
0800 to 0859		0	1	59	3	0	1	1	0	0	1	
0900 to 0959		0	3	28	0	0	4	0	0	0	0	
1000 to 1059		0	1	15	2	5	2	2	0	1	1	
1100 to 1159		0	0	23	2	4	2	2	0	0	3	
1200 to 1259	0	0	2	13	5	0	0	1	0	0	1	
1300 to 1359	0	5	2	23	3	1	0	1	0	0	0	
1400 to 1459	1	4	5	29	5	0	2	1	0	0	0	
1500 to 1559	0	2	1	5	4	0	0	4	0	1	1	
1600 to 1659	0	0			3	2	1	1	0	1		
1700 to 1759	0	2					0	0	1	0		
1800 to 1859												
1900 to 1959												
Total	**1**	**14**	**15**	**195**	**27**	**12**	**15**	**13**	**4**	**3**	**7**	**0**

Date:	5/15	5/16	5/17	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25	5/26
Observation Time-Start:					8:00	8:00	9:40	7:30	7:20	8:00	7:30	8:00
Observation Time-End:					16:05	16:30	17:15	17:00	17:00	17:15	16:00	16:00
Military Time (hrs)												
0600 to 0659												
0700 to 0759								0	0		0	
0800 to 0859					0	0		0	0	1	0	0
0900 to 0959					0	0	0	0	0	0	0	0
1000 to 1059					0	0	0	0	0	0	0	0
1100 to 1159					3	0	0	0	0	0	0	0
1200 to 1259					0	0	0	1	0	0	0	0
1300 to 1359					0	0	1	0	0	0	1	0
1400 to 1459					0	0	0	0	0	0	0	0
1500 to 1559					0	0	0	0	1	0	0	0
1600 to 1659					0	0	0	0	0	0		
1700 to 1759							0			0		
1800 to 1859												
1900 to 1959												
Total	**0**	**0**	**0**	**0**	**3**	**0**	**1**	**1**	**1**	**1**	**1**	**0**

Table 4. (Continued)

Date:	5/27	5/28	5/29	5/30	5/31	6/1	6/2	6/3	6/4	6/5	6/6	*Season Total*
Observation Time-Start:	7:30	8:00	7:30	8:00	9:10	8:00	7:30	7:30	7:20	8:00	7:30	
Observation Time-End:	15:55	16:00	17:15	17:10	17:15	17:15	15:50	16:30	15:50	15:40	14:00	
Military Time (hrs)												
0600 to 0659												**0**
0700 to 0759	0		0				0	0	0		0	**7**
0800 to 0859	0	0	0	0		0	0	0	0	0	0	**67**
0900 to 0959	0	1	0	0	1	0	0	0	0	0	0	**37**
1000 to 1059	0	0	0	0	0	0	0	0	0	0	0	**29**
1100 to 1159	0	0	0	0	0	0	0	0	0	0	0	**39**
1200 to 1259	0	0	0	0	0	0	0	0	0	0	0	**23**
1300 to 1359	0	0	0	0	0	0	0	0	0	0	0	**37**
1400 to 1459	0	0	0	0	0	0	0	0	0	0		**47**
1500 to 1559	0	0	0	0	0	0	0	0	0	0		**19**
1600 to 1659			0	0	0	0		0				**8**
1700 to 1759			0	0	0	0						**3**
1800 to 1859												**0**
1900 to 1959												**0**
Total	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**316**

Table 5. Hourly summary of daily Gizzard Shad passage at the Safe Harbor fish passage facility in 2019.

Date:	5/3	5/4	5/5	5/6	5/7	5/8	5/9	5/10	5/11	5/12	5/13	5/14
Observation Time-Start:	12:50	7:30	7:35	8:00	8:00	7:30	7:30	8:30	7:15	8:00	7:30	
Observation Time-End:	17:15	17:20	16:00	16:00	16:25	16:30	17:20	18:00	17:15	17:15	15:45	
Military Time (hrs)												
0600 to 0659												
0700 to 0759		17	7			1	64	0	25		21	
0800 to 0859		26	117	467	218	393	99	148	139	122	32	
0900 to 0959		38	177	309	65	315	135	331	153	185	17	
1000 to 1059		1	170	322	43	395	362	273	554	26	9	
1100 to 1159		4	22	226	46	240	181	74	514	85	6	
1200 to 1259	168	14	51	126	70	117	355	155	48	132	3	
1300 to 1359	35	45	15	163	124	150	220	104	106	93	0	
1400 to 1459	20	61	34	320	142	302	191	47	87	123	6	
1500 to 1559	12	165	50	282	127	55	64	58	86	94	1	
1600 to 1659	8	309			72	133	157	40	48	84		
1700 to 1759	7	255					48		61	55		
1800 to 1859												
1900 to 1959												
Total	**250**	**935**	**643**	**2,215**	**907**	**2,101**	**1,876**	**1,230**	**1,821**	**999**	**95**	**0**

Date:	5/15	5/16	5/17	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25	5/26
Observation Time-Start:					8:00	8:00	9:40	7:30	7:20	8:00	7:30	8:00
Observation Time-End:					16:05	16:30	17:15	17:00	17:00	17:15	16:00	16:00
Military Time (hrs)												
0600 to 0659												
0700 to 0759								128	127		116	
0800 to 0859					22	108		62	43	438	163	676
0900 to 0959					106	62	231	100	29	53	63	127
1000 to 1059					93	113	85	72	26	79	51	115
1100 to 1159					92	57	127	64	61	109	48	48
1200 to 1259					76	76	91	97	27	141	51	126
1300 to 1359					129	70	121	88	33	73	107	138
1400 to 1459					38	103	65	32	58	50	99	67
1500 to 1559					35	58	51	9	36	66	249	191
1600 to 1659					7	15	36	85	28	56		
1700 to 1759							11			36		
1800 to 1859												
1900 to 1959												
Total	**0**	**0**	**0**	**0**	**598**	**662**	**818**	**737**	**468**	**1,101**	**947**	**1,488**

Table 5. (Continued)

Date:	5/27	5/28	5/29	5/30	5/31	6/1	6/2	6/3	6/4	6/5	6/6	*Season Total*
Observation Time-Start:	7:30	8:00	7:30	8:00	9:10	8:00	7:30	7:30	7:20	8:00	7:30	
Observation Time-End:	15:55	16:00	17:15	17:10	17:15	17:15	15:50	16:30	15:50	15:40	14:00	
Military Time (hrs)												
0600 to 0659												**0**
0700 to 0759	6		148				16	0	10		12	**698**
0800 to 0859	1,660	495	322	128		118	22	0	6	5	14	**6,043**
0900 to 0959	1,080	465	344	61	31	62	3	0	7	9	16	**4,574**
1000 to 1059	546	375	141	43	149	78	2	16	6	6	8	**4,159**
1100 to 1159	387	389	124	22	137	54	13	2	2	3	17	**3,154**
1200 to 1259	458	331	139	72	126	72	18	7	12	8	13	**3,180**
1300 to 1359	327	253	58	44	102	61	6	30	1	7	15	**2,718**
1400 to 1459	148	158	94	28	94	59	5	13	0	9		**2,453**
1500 to 1559	186	117	39	46	125	32	0	18	1	4		**2,257**
1600 to 1659			35	53	84	6		11				**1,267**
1700 to 1759			13	32	123	3						**644**
1800 to 1859												**0**
1900 to 1959												**0**
Total	**4,798**	**2,583**	**1,457**	**529**	**971**	**545**	**85**	**97**	**45**	**51**	**95**	**31,147**