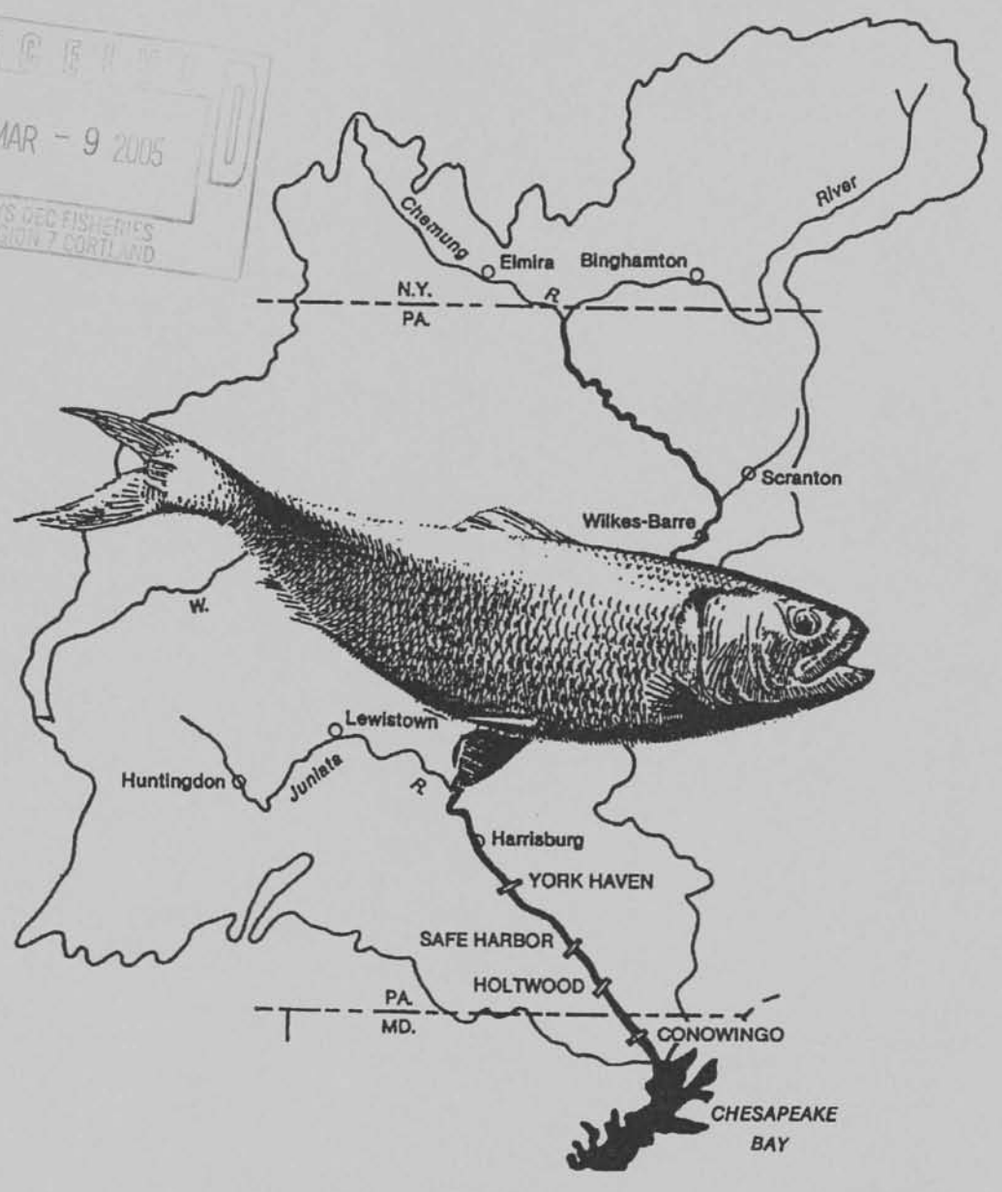
Restoration of American Shad to the Susquehanna River

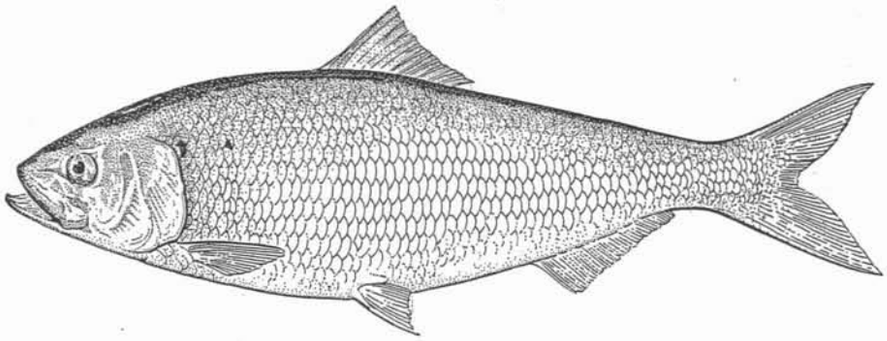
Annual Progress Report
2004



Susquehanna River
Anadromous Fish Restoration Committee

February 2005

RESTORATION OF AMERICAN SHAD TO THE SUSQUEHANNA RIVER



ANNUAL PROGRESS REPORT

2004

SUSQUEHANNA RIVER ANADROMOUS FISH RESTORATION COOPERATIVE

Maryland Department of Natural Resources
New York Div. of Fish, Wildlife & Marine Resources
Pennsylvania Fish and Boat Commission
Susquehanna River Basin Commission
United States Fish and Wildlife Service
NOAA Fisheries

FEBRUARY 2005

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EXECUTIVE SUMMARY

This 2004 Annual Report of the Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC) presents results from activities and studies directed at restoring American shad to the Susquehanna River. Rebuilding anadromous American shad and river herring stocks is based on hatchery releases and natural reproduction of adult fish directly passed through fish lifts at Conowingo, Holtwood, Safe Harbor dams and a fish ladder at York Haven dam. The restoration program represents a continuing commitment among all parties to return migratory fishes to historic spawning and nursery waters above dams in the Susquehanna River.

Spring 2004 was characterized by frequent precipitation, higher than normal streamflows and rapidly warming water temperatures. River flow as measured at Holtwood fluctuated without trend between 44,000 and 82,000 cfs during mid-April through May. Temperature remained in the upper 50s to mid-60s (°F) until second week of May then rose quickly to the mid-70s by the third week of May. The Conowingo East lift began operations on April 12, shad first appeared in abundance on April 21, and the lift operated every day thereafter through May 31 when high temperature and low catch terminated operations. For the season the East lift operated 44 days, made 590 lifts and passed 715,664 fish representing 30 taxa. Gizzard shad (602,677) and American shad (109,360) comprised over 99% of all fish passed. Other alosines included only 101 blueback herring and 89 alewives. About 85% of the season total of American shad passed the East lift prior to May 16. A total of 45 Maryland DNR tags were observed here most of which were 2004 fish tagged in the tailrace.

The Conowingo West lift startup was delayed until May 13 due to damaged entrance weirs. Thereafter, the facility operated on 14 days until May 28, fishing for 74.3 hours and making 151 separate lifts. Total catch amounted to 37,589 fish of 31 taxa including 22,899 gizzard shad, 4,839 channel catfish, 3,426 American shad, and 2,702 carp. Only one blueback herring and no alewives or hickory shad were taken. Sex ratio in the American shad run was 1.9 to 1 favoring females. Every 50th shad collected throughout the season was killed for otolith analysis and scale samples. A total of 1,055 shad were used for tank spawning on-site at Conowingo Dam and no fish were transported to Maryland or upstream in 2004.

The tailrace lift at Holtwood operated on 39 days during April 26 through June 3, fishing for 294 hours and making 431 lifts. The spillway lift operated on 14 days making 71 lifts in 74 hours. Spillage occurred all day and every day at Holtwood during the 2004 season. This coupled with rapid rise in water temperature led to the lowest annual shad passage count since lift startup in 1997. A total of only 3,428 American shad were passed in 2004, all but 16 fish at the tailrace lift. Other fish in combined Holtwood collections included 170,411 gizzard shad and 3,735 others. Shad passage rate at Holtwood in 2004 was only 3.1% of those passed at Conowingo East lift, a substantial decrease from all other years.

The Safe Harbor fish lift operated for 285 hours during 33 days between May 3 and June 4 and made 265 lifts. Total fish passage for the season was 148,020 fish including 2,109 American shad and 127,628 gizzard shad. Most common other fish were quillback, channel catfish, shorthead redhorse and walleye. Safe Harbor passed about 61.5% of the American shad counted at Holtwood.

Fish ladder operations at York Haven's East Channel Dam occurred on 19 days between May 17 and June 4 with American shad observed passing the site on all days. For the season, total fish passage at York Haven amounted to 99,973 fish including 84,234 gizzard shad, 219 American shad (10% of Safe Harbor total), and 15,520 others (16 species). Most American shad (76%) passed York Haven during the period May 22-27.

Maryland DNR collected shad for tag and release by angling in the Conowingo tailrace. Total catch was 405 shad of which 402 were tagged and released. Using recapture (tag sightings) from the East lift (37 tags), a shad population index was calculated for the Conowingo tailrace of 1,005,797, the highest annual estimate to date. DNR cautions that this number is likely over-estimated due to poor water clarity (missed tags) at the East lift. Scale analysis from angling samples showed that most males were aged 5 with 18% repeat spawning, and most females were ages 5-6 with 15% repeat spawners.

Based on analysis of 158 readable otoliths from adult shad taken at Conowingo West lift, 113 (72%) were of hatchery origin and 45 (28%) were wild. This is the second lowest percentage of wild fish in collections since 1995. The majority of hatchery fish (88 or 78%) carried the single day 3 or 5 tetracycline mark suggesting that they were stocked in the Juniata River or mainstem Susquehanna below Sunbury. Remaining tagged fish (1 to 7 each) carried various triple, quadruple, and quintuple marks. Based on the analysis of hatchery vs. wild adult shad returning to Conowingo, age of fish, and known stocking numbers, PFBC calculated that, on average for the fully recruited year-classes of 1986-1997, it took an average 178 stocked larvae, 133 stocked fingerlings, and 0.81 transplanted or passed adults to produce each adult shad return.

The Wyatt Group was contracted by PFBC to collect shad eggs from the Hudson River at Coxsackie, NY and PFBC completed Delaware River egg collections at Smithfield Beach, PA. The Hudson produced 9.4 million eggs with 74.9% viability. Delaware River collections amounted to 2.4 million eggs with 43% viable. In a fourth year attempt at tank spawning at Conowingo Dam, Normandeau Associates used two tanks and completed 10 spawning trials using 1,055 American shad (420 females) to produce 4.74 million eggs of which 20% were viable. Fish received 150 ug doses of LHRH hormone in either pellet or liquid injections. In a second year attempt, Normandeau also tank spawned hickory shad collected by angling and produced 13.56 million eggs of which 46% were viable. USFWS used gill nets to collect adult

shad for strip spawning in the lower Susquehanna River near Lapidum. During seven nights of netting in May 11-26, 242 shad were collected (mostly hard or spent) and 752,700 eggs were shipped to Van Dyke with 42% viability. Total American shad egg collections in 2004 amounted to 17.3 million with an overall viability of 54%.

In 2004, Van Dyke Hatchery produced 5.67 million American shad fry and 6.1 million hickory shad larvae. Of the American shad, 4.73 million were stocked in the Susquehanna drainage as follows: 2.6 million in the Juniata River; 283,000 in the Susquehanna below Sunbury; 828,000 in NY waters of the Susquehanna and Chemung rivers; 480,000 in the North Branch in PA; 282,000 in the West Branch; and 256,000 in four lower river tributaries. Van Dyke American shad were also stocked into the Schuylkill (421,600), Lehigh (366,400) and Raritan (118,900) rivers. Hickory shad larvae were stocked at the Muddy Creek access in Conowingo Pond (3.37 million), the Delaware River (1.816 million) and two Delaware tributaries (933,500). All fish were distinctively marked with tetracycline.

As was the case in 2002 and 2003, juvenile shad collections in the Susquehanna River were very weak in 2004. Van Dyke hatchery stocked 4.7 million marked shad larvae, less than half the number from 2003. Also, few adults passed into spawning waters above Safe Harbor and York Haven dams. Juvenile collections in 2004 were severely impacted by unusual high water events in late July, and in early and late September. The latter events coincided with passage of the remnants of Hurricanes Francis and Ivan. Haul seining at Columbia, PA was scheduled for 15 weeks but only 11 events occurred due to frequent high water. At total of 25 American shad were taken in 66 hauls, all between August 31 and September 9. No shad were taken with lift net at Holtwood's inner forebay in 240 lifts on 24 dates between September 14 and December 1. Catch per effort of zero at Holtwood was the lowest recorded in 20 years. During early October to early December, Peach Bottom screens were sampled 23 times and intake strainers at Conowingo 16 times. No juvenile shad were collected at these sites. During July-September seine sampling in the upper Chesapeake Bay, Maryland DNR collected 204 juvenile American shad in 57 hauls.

Otoliths from the 25 juvenile shad collected at Columbia, PA were examined for tetracycline marks and all were shown to have originated from hatchery releases. All otoliths displayed triple marks indicating they were stocked at various locations in the Juniata or mainstem Susquehanna River below Sunbury. At the time of this printing, shad taken in Maryland collections were not yet analyzed for hatchery marks.

Fish passage facility maintenance, operations, fish counting and reporting were paid by each of the affected utility companies in accordance with guidelines established by separate fish passage advisory committees. American shad egg collections from the Hudson and Delaware rivers, Van

Dyke hatchery culture and marking, juvenile shad netting and other surveys above Conowingo Dam, and otolith mark analysis were funded by the PA Fish and Boat Commission. Maryland DNR funded the adult shad population assessment, stock analysis, and juvenile shad seining in the upper Chesapeake Bay. USFWS covered most costs associated with lower Susquehanna River shad egg collections. Costs related to Conowingo West fish lift operations including tank spawning and hormones were paid from a SRAFRC contributed funds account administered by USFWS. This account also paid for services of a contract fisherman to work with USFWS on Susquehanna egg collections. Contributions to the special account in 2004 came from Maryland DNR and PFBC.

Additional information on activities discussed in this Annual Report can be obtained from individual Job authors or by contacting the Susquehanna River Coordinator at:

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Job I – Part 1
SUMMARY OF OPERATIONS AT THE CONOWINGO DAM EAST FISH PASSAGE FACILITY - SPRING 2004

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INTRODUCTION

Susquehanna Electric Company (SECO), a subsidiary of Exelon Generation, has operated a fish passage facility (West lift) at its Conowingo Hydroelectric Station since 1972. Lift operations are part of a cooperative private, state, and federal effort to restore American shad (*Alosa sapidissima*) and other migratory fishes to the Susquehanna River. In accordance with the restoration plan, the operational goal had been to monitor fish populations below Conowingo Dam and transport pre-spawned migratory fishes upriver.

In 1988, the former PECO Energy Company negotiated an agreement with state and federal resource agencies and private organizations to enhance restoration of American shad and other anadromous species to the Susquehanna River. A major element of this agreement was for PECO Energy Company to construct an East Fish Passage Facility (East lift) at Conowingo Dam. Construction of the East lift commenced in April 1990 and it was operational by spring 1991.

With the completion of fishways at Holtwood, Safe Harbor, and York Haven dams, the East lift has been operated to pass fish directly into Conowingo Pond since spring 1997. Objectives of 2004 operation were: (1) monitor passage of migratory and resident fishes through the fishway; and (2) assess fishway and trough effectiveness and make modifications as feasible.

CONOWINGO OPERATION

Project Operation

The Conowingo Hydroelectric Station, built in 1928, is located at river mile 10 on the Susquehanna River (RMC 1992). The powerhouse has a peaking generating capacity of 549.5 MW and a hydraulic capacity of approximately 85,000 cfs. Flows in excess of station draft are spilled over two regulating and 50 crest gates. The powerhouse contains seven vertical Francis (numbered 1 through 7) and four Kaplan (numbered 8 through 11) turbines. The seven Francis

units have been equipped with aeration systems that permit a unit to draw air into the unit (vented mode) or operate conventionally (unvented mode). The four original Kaplan turbines installed in 1964 were replaced over a period of four years (1992 to 1996), with more efficient mixed-flow Kaplan type turbines.

Minimum flow releases from the station during the spring spawning and fishway operating season follow the schedule outlined in the settlement agreement. Minimum flows of 10,000, and 7,500 cfs were maintained from 1 to 30 April and 1 to 31 May, respectively.

Fishway Operation

East lift operation began 12 April on an every other day basis. Lift operations were suspended from 15 through 18 April due to a high flow event, (river flows greater than 163,000 cfs on 16 April). Operations resumed on 19 April with daily operation occurring from 21 April to 31 May. Operations ended for the season on 31 May due to an extended period of high water temperature and the advanced spawning condition of American shad. A mechanical problem with the East lift's downstream entrance gate occurred near season end and will be repaired prior to the start of shad migration in 2005. The lift was operated a total of 44 days during the 2004 season.

Generally, daily operation began at 0800 h and continued until approximately 1900 h. Fishway operation was conducted by a staff of three people: a lift operator, a supervising biologist, and a biological technician.

The mechanical aspects of the East lift operation in 2004 were similar to those described in RMC (1992) and Normandeau Associates, Inc. (1999). Fishing time and/or lift frequency was determined by fish abundance, but the hopper was cycled at least hourly throughout the day. The method of lift operation was also influenced by fish abundance. When a great number of fish were in the fishing channel, the crowder was not operated; instead the crowder screen was raised and then lowered trapping fish over the hopper. This mode of operation, called "fast fish", involved leaving the crowder in the normal fishing position and raising the hopper frequently to remove fish that accumulated in the holding channel.

The specific entrance(s) used to attract fishes was dictated by the station discharge and which turbine units were operating. For example, when turbine units 8, 9, 10, and 11 or any combination of large turbines were operating, entrance C was the primary entrance used to attract

fishes. Under these conditions the attraction flow through the other entrances was negated or disrupted. Entrance C was used extensively to attract fishes during the 2004 season.

Fish Counts

Fish that were lifted and sluiced into the trough were guided by a series of fixed screens. The fixed screens directed the fish to swim up and through a 3 ft wide channel and past a 4 ft by 10 ft counting window located on the west wall of the trough. Fish passing the counting window were identified to species and enumerated by a biologist and/or technician. Passage of fish by the window and out of the trough system was controlled by a set of gates located downstream of the counting window. During periods of peak passage, two people were used to identify and count fish.

At the end of each hour, fish passage data were recorded on data sheets and entered into a Microsoft Excel worksheet 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 distributed in hard copy 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 plant personnel and other cooperators.

RESULTS

Relative Abundance

The number of fishes collected and passed by the Conowingo Dam East fish lift is presented in Table 1. A total of 715,664 fish of 29 species and one hybrid was passed upstream into Conowingo Pond. Gizzard shad (602,677), American shad (109,360), channel catfish (928), and white perch (512) were the dominant species passed. Gizzard shad and American shad comprised 84% and 15% respectively of the season total; the two species together accounted for 99% of the total fish passed. Other common fishes included striped bass (391) and quillback (308). Alosids, (American shad, blueback herring, and alewife) comprised 15% of the total catch. Peak passage occurred on 25 April when 82,119 fish (nearly 94% gizzard shad) were passed.

American Shad Passage

The East lift collected and passed 109,360 American shad (Table 1). The first shad was passed on 14 April. Collection and passage of shad varied daily with 17.5% (19,117) of the shad passed from 14 to 30 April, 71.5% (78,258) passed from 1 to 15 May, and 11% (11,985) passed from 16 to 31 May, (Figures 1 and 2). The lift collected and passed over 10,000 American shad on two separate days. On 7 of the 44 days of operation, American shad passage exceeded 5,000 fish. Peak passage occurred on 2 May when 21,065 American shad were passed.

American shad were collected at water temperatures of 50.0 to 77.0°F and at natural river flows of 44,000 to 81,900 cfs (Table 2 and Figure 1). The natural river flow and water temperature during the four highest days of passage, (2, 8, 9, and 10 May), ranged from 54,200 cfs to 61,200 cfs and 61.2°F to 66.2°F, respectively. The average daily river flow on those days when American shad passage exceeded 1,000 fish was approximately 59,316 cfs. The average daily river flow during the operational season was 60,170 cfs.

The hourly passage of American shad for the East lift is given in Table 3. Peak passage of shad (64,413 or nearly 59% of total passage) occurred between 1100 and 1559 h. The highest hourly shad passage rate was recorded from 1400 to 1459 h. Generally, shad passage increased during the morning hours, peaked and remained steady during the midday hours, then gradually declined throughout the late afternoon and early evening hours.

Alosines

A total of 89 alewife and 101 blueback herring was collected and passed (Table 1). The alewives were passed between 26 April and 9 May while the blueback herring were passed between 28 April and 23 May. No hickory shad were collected or passed in spring 2004. Most blueback herring (88%) were passed from 12 to 18 May at a water temperature ranging from 67.7 to 75.2°F and an average river flow of 58,800 cfs.

SUMMARY

East fish lift operation was initiated on 12 April with the first American shad passed on 14 April. The East fish lift successfully passed 109,360 American shad from 14 April through 31 May. The total number of American shad passed during the 2004 season was the fourth highest

passage total since East lift operations began in 1991 and the fifth consecutive year in which American shad passage at Conowingo has surpassed 100,000 fish (Table 4).

Fish viewing conditions were somewhat impacted by the occurrence of sustained spring river flows in 2004. Water clarity conditions prevented technicians from observing more than 24 inches of the viewing area throughout most of the season. Visual counting accuracy was maximized by utilizing two people during periods of increased fish passage and/or poor viewing conditions

Modifications made to the fish trough, particularly the valve grating and hopper trough chute since 1999 have diminished the potential for the valve grating to clog with various types of debris and have decreased the number of American shad lift mortalities observed throughout the last several fish passage seasons. Since the valve grating was modified prior to the start of the 2000 season, loss of water flow in the trough has not occurred, particularly during high river flow periods when large amounts of debris may enter the trough through the fish exit area. An aeration system was also installed prior to the 2000 passage season to diminish low dissolved oxygen levels when the American shad population is heavy in the trough. Prior to fishway operations in 2002, a 30 inch diameter fiberglass elbow was attached to the hopper extension chute, which had been installed in 2001. The modification allows fish to enter the trough center stream, instead of being directed toward the east trough wall. A decrease in lift mortalities has also been observed since the fiberglass elbow was installed. A total of 207 American shad lift mortalities, (0.2% of the total shad passed), were observed in 2004, lower than the lift mortalities observed in recent years (0.3% to 1.0%) and less than values observed during trap and transport operations (1.5% to 10.5%).

RECOMMENDATIONS

1) Continue to operate the East lift at Conowingo Dam per annual guidelines developed and approved by the Susquehanna River Technical Committee. Lift operation should adhere to the guidelines; however, flexibility must remain with operating personnel to maximize fishway performance and fish passage.

2) Continue the use of two fish counters during periods of increased fish passage to accurately reflect the number of fish that pass through the East lift.

3) Continue to inspect cables, limit switches, and lift components to enhance season operability, and continue to evaluate effectiveness of fish trough modifications.

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RMC. 1992. Summary of the operations of the Conowingo Dam fish passage facilities in spring 1991. Prepared for Susquehanna Electric Company, Darlington, MD.

Normandeau Associates, Inc. 1999. Summary of the operations at the Conowingo Dam East fish passage facility in spring, 1998. Prepared for Susquehanna Electric Company, Darlington, MD.

Table 1

Summary of the daily number of fish passed by the Conowingo Dam East Fish Passage Facility in 2004. No operation on April 13, 15, 16, 17, 18, and 20.

Date:	*4/12*	*4/14*	*4/19*	*4/21*	*4/22*	*4/23*	*4/24*	*4/25*
Start Fishing Time:	*10:30*	*10:30*	*10:15*	*10:30*	*10:15*	*10:15*	*7:30*	*7:30*
End Fishing Time:	*14:30*	*15:00*	*15:15*	*17:00*	*17:00*	*18:00*	*18:30*	*18:30*
Hours of Operation:	*4.0*	*4.5*	*5.0*	*6.5*	*6.8*	*7.8*	*11.0*	*11.0*
Number of Lifts:	*4*	*5*	*7*	*9*	*14*	*16*	*24*	*22*
Water Temperature (°F):	*50*	*50*	*53.6*	*60.5*	*62.6*	*62.6*	*63*	*64.4*
American Shad	0	1	0	193	142	4,419	3,233	5,177
Hickory shad	0	0	0	0	0	0	0	0
Blueback Herring	0	0	0	0	0	0	0	0
Alewife	0	0	0	0	0	0	0	0
Gizzard shad	339	1,738	2,470	8,619	20,990	34,193	24,800	76,919
Sea lamprey	0	1	0	1	2	2	2	4
Rainbow trout	0	0	0	0	1	1	0	0
Brown trout	0	0	0	0	0	0	0	1
Carp	0	0	0	0	0	1	1	0
Comely shiner	0	0	0	0	0	0	0	0
Quillback	0	0	2	3	11	1	5	1
White sucker	0	0	0	2	0	0	3	2
Shorthead redhorse	0	0	0	8	4	0	4	0
White catfish	0	0	0	0	0	0	0	0
Yellow bullhead	0	0	0	0	0	1	0	0
Brown bullhead	0	0	0	0	1	0	0	0
Channel catfish	0	0	4	15	4	3	1	2
Striped bass	0	0	0	0	0	0	0	0
White perch	0	0	0	0	2	0	2	2
Rock bass	0	0	0	0	0	0	0	1
Redbreast sunfish	0	0	0	0	0	0	0	0
Green sunfish	0	0	0	0	0	0	0	0
Pumpkinseed	0	0	0	0	0	0	0	0
Bluegill	0	0	1	0	0	0	0	2
Smallmouth bass	0	0	0	5	7	1	0	6
Largemouth bass	0	0	0	0	0	0	0	0
White crappie	0	0	0	0	0	0	0	0
Black crappie	0	0	0	0	0	0	0	0
Yellow perch	0	0	0	0	0	0	1	0
Walleye	0	0	2	2	6	0	0	2
Splake (Brook x Lake Trout)	0	0	0	0	0	0	0	0
TOTAL	*339*	*1,740*	*2,479*	*8,848*	*21,170*	*38,622*	*28,052*	*82,119*

Table 1

Continued.

Date:	*4/26*	*4/27*	*4/28*	*4/29*	*4/30*	*5/1*	*5/2*	*5/3*
Start Fishing Time:	*8:00*	*8:45*	*8:00*	*9:00*	*7:45*	*8:00*	*7:40*	*8:00*
End Fishing Time:	*18:20*	*17:00*	*16:45*	*15:45*	*15:00*	*18:30*	*19:00*	*18:20*
Hours of Operation:	*10.3*	*8.3*	*8.8*	*6.8*	*7.3*	*10.5*	*11.3*	*10.3*
Number of Lifts:	*17*	*15*	*10*	*7*	*9*	*17*	*27*	*21*
Water Temperature (°F):	*63.9*	*63*	*59*	*58.9*	*59.6*	*61*	*61.2*	*62.6*
American Shad	4,169	1,706	76	1	0	3,001	21,065	5,287
Hickory shad	0	0	0	0	0	0	0	0
Blueback Herring	0	0	1	0	0	1	0	0
Alewife	1	0	0	0	0	0	23	0
Gizzard shad	15,030	16,338	11,788	5,458	10,707	23,560	27,465	23,434
Sea lamprey	5	0	3	0	0	1	7	8
Rainbow trout	0	0	0	0	0	1	0	0
Brown trout	0	0	0	0	0	0	0	0
Carp	0	4	4	1	0	1	0	3
Comely shiner	0	3	0	0	0	0	0	0
Quillback	1	6	1	0	0	1	3	3
White sucker	0	0	1	0	0	0	0	1
Shorthead redhorse	0	9	0	1	3	8	3	41
White catfish	0	0	0	0	0	0	0	0
Yellow bullhead	0	0	0	0	0	0	0	0
Brown bullhead	7	20	21	0	0	1	0	2
Channel catfish	13	37	24	3	6	12	3	26
Striped bass	1	1	0	0	0	0	0	1
White perch	36	5	0	0	0	4	1	4
Rock bass	4	0	0	0	0	0	0	0
Redbreast sunfish	0	0	0	0	0	0	0	0
Green sunfish	1	0	0	0	0	0	0	0
Pumpkinseed	0	0	0	0	1	0	0	0
Bluegill	1	0	0	0	0	0	0	0
Smallmouth bass	4	3	1	0	2	2	12	4
Largemouth bass	0	0	0	0	0	1	1	0
White crappie	0	0	0	0	0	0	0	1
Black crappie	0	0	0	0	0	0	0	0
Yellow perch	2	0	1	0	0	0	0	0
Walleye	4	1	1	3	1	5	1	10
Splake (Brook x Lake Trout)	0	0	0	0	0	0	0	1
TOTAL	*19,279*	*18,133*	*11,922*	*5,467*	*10,720*	*26,599*	*48,584*	*28,826*

Table 1

Continued.

Date:	*5/4*	*5/5*	*5/6*	*5/7*	*5/8*	*5/9*	*5/10*	*5/11*
Start Fishing Time:	*7:30*	*8:00*	*8:00*	*8:00*	*8:00*	*7:30*	*8:00*	*8:00*
End Fishing Time:	*18:15*	*17:00*	*18:00*	*18:00*	*18:30*	*19:00*	*18:00*	*17:30*
Hours of Operation:	*10.8*	*9.0*	*10.0*	*10.0*	*10.5*	*11.5*	*10.0*	*9.5*
Number of Lifts:	*15*	*14*	*13*	*14*	*22*	*21*	*22*	*7*
Water Temperature (°F):	*62.1*	*64.4*	*61.9*	*63*	*62.3*	*62.3*	*66.2*	*68*
American Shad	1,372	3,043	1,186	3,554	7,184	10,034	7,344	209
Hickory shad	0	0	0	0	0	0	0	0
Blueback Herring	0	8	0	0	0	0	0	0
Alewife	1	0	0	12	0	52	0	0
Gizzard shad	19,270	10,330	14,945	16,461	19,784	32,458	20,265	9,930
Sea lamprey	0	1	2	1	3	0	1	0
Rainbow trout	0	1	0	0	1	0	0	0
Brown trout	0	0	0	0	0	0	0	0
Carp	0	0	0	0	3	6	2	1
Comely shiner	0	0	0	0	0	0	0	0
Quillback	9	3	2	1	2	0	45	2
White sucker	0	0	1	0	0	0	0	0
Shorthead redhorse	1	3	3	1	6	0	7	3
White catfish	0	0	0	0	0	0	0	0
Yellow bullhead	0	0	0	0	0	0	0	0
Brown bullhead	3	0	1	0	0	0	1	0
Channel catfish	10	4	9	8	4	4	6	121
Striped bass	2	0	2	0	1	1	1	0
White perch	43	28	13	6	51	42	10	2
Rock bass	0	1	0	0	0	0	0	0
Redbreast sunfish	0	0	0	1	0	0	0	0
Green sunfish	0	0	0	0	0	0	0	0
Pumpkinseed	0	0	0	0	0	0	0	0
Bluegill	0	0	1	0	0	3	0	1
Smallmouth bass	9	1	4	1	6	6	7	0
Largemouth bass	1	0	0	0	0	0	0	0
White crappie	0	0	0	0	0	0	0	0
Black crappie	0	0	0	0	0	0	0	0
Yellow perch	0	0	0	0	0	0	0	0
Walleye	5	5	10	2	3	6	4	4
Splake (Brook x Lake Trout)	0	0	0	0	0	0	0	0
TOTAL	*20,726*	*13,428*	*16,179*	*20,048*	*27,048*	*42,612*	*27,693*	*10,273*

Table 1

Continued.

Date:	*5/12*	*5/13*	*5/14*	*5/15*	*5/16*	*5/17*	*5/18*	*5/19*
Start Fishing Time:	*7:30*	*7:30*	*8:00*	*7:30*	*7:40*	*8:00*	*7:30*	*8:00*
End Fishing Time:	*18:00*	*18:00*	*17:45*	*18:00*	*18:00*	*17:20*	*18:00*	*17:30*
Hours of Operation:	*10.5*	*10.5*	*9.8*	*10.5*	*10.3*	*9.3*	*10.5*	*9.5*
Number of Lifts:	*19*	*17*	*17*	*17*	*17*	*15*	*15*	*14*
Water Temperature (°F):	*67.7*	*69.7*	*71.6*	*73.4*	*73.6*	*73.8*	*75.2*	*75.6*
American Shad	5,163	4,821	3,634	1,361	3,837	1,271	1,558	1,310
Hickory shad	0	0	0	0	0	0	0	0
Blueback Herring	39	9	1	1	7	27	5	0
Alewife	0	0	0	0	0	0	0	0
Gizzard shad	21,080	11,064	16,979	21,582	12,472	17,127	15,083	4,606
Sea lamprey	2	0	2	1	1	2	0	0
Rainbow trout	0	0	1	1	0	0	0	0
Brown trout	0	2	0	0	0	0	0	0
Carp	2	14	7	2	7	5	17	80
Comely shiner	0	0	0	0	0	0	0	0
Quillback	6	9	44	22	7	18	18	28
White sucker	0	0	0	0	0	0	1	0
Shorthead redhorse	2	0	5	0	0	0	0	0
White catfish	0	0	0	0	0	0	0	0
Yellow bullhead	0	0	0	0	0	0	0	0
Brown bullhead	0	3	5	0	1	0	3	6
Channel catfish	14	13	25	3	16	13	26	48
Striped bass	2	0	3	3	6	10	12	16
White perch	166	50	9	6	1	4	3	4
Rock bass	0	0	0	0	1	0	0	0
Redbreast sunfish	0	0	0	0	0	0	0	0
Green sunfish	0	0	0	0	0	0	0	0
Pumpkinseed	0	0	0	0	0	0	0	0
Bluegill	0	1	2	0	1	0	0	0
Smallmouth bass	8	3	12	7	5	20	10	5
Largemouth bass	0	0	0	2	3	1	0	1
White crappie	0	1	0	0	0	0	0	0
Black crappie	0	0	0	0	0	0	0	0
Yellow perch	0	1	0	0	0	0	0	0
Walleye	4	13	11	2	2	5	6	0
Splake (Brook x Lake Trout)	0	0	0	0	0	0	0	0
TOTAL	*26,488*	*16,004*	*20,740*	*22,993*	*16,367*	*18,503*	*16,742*	*6,104*

Table 1

Continued.

Date:	*5/20*	*5/21*	*5/22*	*5/23*	*5/24*	*5/25*	*5/26*	*5/27*
Start Fishing Time:	*7:30*	*7:35*	*7:30*	*7:50*	*8:00*	*7:30*	*7:30*	*8:00*
End Fishing Time:	*17:30*	*16:15*	*17:15*	*16:30*	*15:30*	*15:30*	*15:30*	*15:30*
Hours of Operation:	*10.0*	*8.7*	*9.8*	*8.7*	*7.5*	*8.0*	*8.0*	*7.5*
Number of Lifts:	*13*	*9*	*13*	*10*	*8*	*8*	*8*	*8*
Water Temperature (°F):	*73.8*	*71.6*	*74.3*	*75*	*76.1*	*76.1*	*77*	*77*
American Shad	1,104	133	898	1,176	28	87	112	70
Hickory shad	0	0	0	0	0	0	0	0
Blueback Herring	0	1	0	1	0	0	0	0
Alewife	0	0	0	0	0	0	0	0
Gizzard shad	12,525	1,479	5,610	5,256	3,019	3,559	972	1,000
Sea lamprey	0	0	0	6	0	0	0	0
Rainbow trout	1	0	0	0	0	0	0	0
Brown trout	0	0	0	0	0	0	0	0
Carp	1	2	6	39	8	8	21	6
Comely shiner	0	0	0	0	0	0	0	185
Quillback	5	2	6	5	2	11	14	3
White sucker	0	0	0	0	0	0	0	0
Shorthead redhorse	0	0	0	0	0	0	0	1
White catfish	0	0	0	0	5	0	0	0
Yellow bullhead	0	1	0	0	0	0	0	0
Brown bullhead	2	3	1	5	40	15	0	3
Channel catfish	13	21	3	7	139	67	67	26
Striped bass	19	39	18	21	34	38	27	52
White perch	0	0	0	3	1	0	2	10
Rock bass	0	0	0	0	0	0	0	0
Redbreast sunfish	0	0	0	2	3	0	0	0
Green sunfish	0	0	0	0	0	0	0	0
Pumpkinseed	0	0	0	0	0	0	0	0
Bluegill	0	0	0	2	0	0	0	0
Smallmouth bass	2	3	4	5	2	3	2	0
Largemouth bass	0	0	0	1	0	0	0	2
White crappie	0	0	1	0	0	0	0	0
Black crappie	0	0	0	0	0	0	0	0
Yellow perch	0	0	0	0	0	0	0	0
Walleye	0	2	0	2	16	1	6	0
Splake (Brook x Lake Trout)	0	0	0	0	0	0	0	0
TOTAL	*13,672*	*1,686*	*6,547*	*6,531*	*3,297*	*3,789*	*1,223*	*1,358*

Table 1

Continued.

Date:	*5/28*	*5/29*	*5/30*	*5/31*	***Totals***
Start Fishing Time:	*7:50*	*7:30*	*7:40*	*7:20*	
End Fishing Time:	*15:45*	*15:30*	*15:40*	*13:30*	
Hours of Operation:	*7.9*	*8.0*	*8.0*	*6.2*	**390.3**
Number of Lifts:	*8*	*8*	*8*	*6*	**590**
Water Temperature (°F):	*76.1*	*73.8*	*73.4*	*72*	
American Shad	103	32	210	56	**109,360**
Hickory shad	0	0	0	0	**0**
Blueback Herring	0	0	0	0	**101**
Alewife	0	0	0	0	**89**
Gizzard shad	1,039	281	155	498	**602,677**
Sea lamprey	0	0	0	0	**58**
Rainbow trout	0	0	0	0	**8**
Brown trout	0	0	0	0	**3**
Carp	3	2	0	0	**257**
Comely shiner	0	3	0	100	**291**
Quillback	0	4	0	2	**308**
White sucker	0	0	0	0	**11**
Shorthead redhorse	0	0	0	0	**113**
White catfish	0	0	0	0	**5**
Yellow bullhead	0	0	0	0	**2**
Brown bullhead	6	11	0	0	**161**
Channel catfish	50	52	1	5	**928**
Striped bass	37	11	25	8	**391**
White perch	0	1	1	0	**512**
Rock bass	0	0	0	0	**7**
Redbreast sunfish	0	0	2	0	**8**
Green sunfish	0	0	0	0	**1**
Pumpkinseed	0	0	0	0	**1**
Bluegill	4	0	0	0	**19**
Smallmouth bass	0	0	0	0	**172**
Largemouth bass	0	0	0	2	**15**
White crappie	0	0	0	0	**3**
Black crappie	0	0	1	0	**1**
Yellow perch	0	0	0	0	**5**
Walleye	2	4	2	1	**156**
Splake (Brook x Lake Trout)	0	0	0	0	**1**
TOTAL	***1,244***	***401***	***397***	***672***	***715,664***

Table 2

Summary of American shad catch, Maryland DNR recaptures, daily average river flow as measured at Holtwood Dam, water temperature, turbidity (secchi), unit operation, entrance gates utilized, attraction flow, and project water elevations during operation of the Conowingo Dam East fish passage facility in 2004. No operation on April 13, 15, 16, 17, 18, and 20.

Date	American Shad Catch	MD DNR Recaptures*	Holtwood River Flow (cfs)	Water Temp. (°F)	Secchi (in)	Maximum Units in Operation	Entrance Gates Utilized	Attraction Flow (cfs)	Elevation (ft)		Crest Gates
									Tailrace	Forebay	
12 April	0	*0*	45,200	*50*	22	11	C	310	21.0-23.0	107.1	0
14 April	1	*0*	81,900	*50*	20	11	C	310	23.0	106.0	0
19 April	0	*0*	79,200	*53.6*	4	11	C	310	23.0	107.8	0
21 April	193	*0*	59,200	*60.5*	16	11	C	310	22.0-23.0	106.3	0
22 April	142	*0*	53,800	*62.6*	22	11	C	310	21.5-23.0	106.1	0
23 April	4,419	*0*	49,800	*62.6*	23	11	C	281	23.0-23.5	107.4	0
24 April	3,233	*1OR*	50,200	*63*	24	9	C	310	19.5-22.5	107.8	0
25 April	5,177	*0*	48,500	*64.4*	23	7	C	310	19.5-22.0	107.3	0
26 April	4,169	*20R,1P*	58,600	*63.9*	23	11	C	310	21.5-23.0	106.7	0
27 April	1,706	*0*	74,200	*63*	16	11	C	310	23.00	105.7	0
28 April	76	*0*	80,800	*59*	14	11	C	310	23.0	105.7	0
29 April	1	*0*	81,000	*58.9*	18	11	C	310	23.00	106.7	0
30 April	0	*0*	72,500	*59.6*	19	11	C	310	23.0-23.5	106.8	0
01 May	3,001	*0*	64,600	*61*	17	11	C	310	23.0-23.5	107.0	0
02 May	21,065	*1P*	54,200	*61.2*	20	7	C	310	19.5-23.0	108.1	0
03 May	5,287	*1OR,1P,1Y*	61,100	*62.6*	20	11	C	310	23.0-23.5	106.2	0
04 May	1,372	*0*	74,500	*62.1*	24	11	C	310	23.5-23.8	108.0	0
05 May	3,043	*0*	75,800	*64.4*	24	11	C	310	23.50	106.5	0
06 May	1,186	*0*	72,600	*61.9*	19	11	C	310	23.50	107.2	0
07 May	3,554	*0*	64,500	*63*	20	11	C	310	23.50	106.5	0
08 May	7,184	*4P*	59,400	*62.3*	19	11	C	310	23.50	106.9	0
09 May	10,034	*3P,1Y*	58,200	*62.3*	22	11	C	310	19.0-23.0	106.6	0
10 May	7,344	*0*	61,200	*66.2*	18	11	C	310	23.50	108.5	0
11 May	209	*0*	60,000	*68*	8	11	C	310	23.50	106.0	0

Table 2

Continued.

Date	American Shad Catch	MD DNR Recaptures*	Holtwood River Flow (cfs)	Water Temp. (°F)	Secchi (in)	Maximum Units in Operation	Entrance Gates Utilized	Attraction Flow (cfs)	Elevation (ft)		Crest Gates
									Tailrace	Forebay	
12 May	5,163	*2OR,6P*	64,000	*67.7*	12	11	C	310	23.50	107.5	0
13 May	4,821	*0*	68,300	*69.7*	20	11	C	310	23.00	107.2	0
14 May	3,634	*3P*	65,100	*71.6*	19	11	C	310	23.30	105.8	0
15 May	1,361	*1OR,1P*	57,000	*73.4*	24	11	C	310	20.0-23.5	107.0	0
16 May	3,837	*6P*	55,200	*73.6*	24	11	C	310	21.0-23.0	107.4	0
17 May	1,271	*1P*	52,700	*73.8*	24	11	C	310	22.5-23.0	106.8	0
18 May	1,558	*2P*	49,300	*75.2*	24	11	C	310	22.5-23.5	106.5	0
19 May	1,310	*2P*	46,300	*75.6*	22	11	C	310	21.0-23.5	106.5	0
20 May	1,104	*1P*	44,300	*73.8*	19	11	C	310	22.0-23.5	106.8	0
21 May	133	*0*	44,000	*71.6*	20	11	C	310	22.5-23.0	107.5	0
22 May	898	*2P*	45,800	*74.3*	22	11	A,C	310	19.0-23.0	107.6	0
23 May	1,176	*2P*	53,300	*75*	21	11	A,C	310	16.0-22.5	107.7	0
24 May	28	*0*	69,400	*76.1*	19	11	C	310	23.00	105.4	0
25 May	87	*0*	64,100	*76.1*	18	11	C	310	23.00	105.0	0
26 May	112	*0*	53,800	*77*	20	11	C	310	17.0-23.0	107.2	0
27 May	70	*0*	53,300	*77*	20	11	C	310	23.00	107.9	0
28 May	103	*0*	63,700	*76.1*	24	11	C	310	22.50	108.1	0
29 May	32	*0*	58,500	*73.8*	14	11	C	310	21.5-23.0	107.0	0
30 May	210	*0*	50,500	*73.4*	20	7	A,C	310	16.0-21.5	108.0	0
31 May	56	*0*	47,900	*72*	16	7	A,C	310/450	17.0-21.5	107.9	0

* Tag color: OR = orange, P = pink, Y = yellow

Table 3

Hourly summary of American shad passage at the Conowingo Dam East Fish Passage Facility in 2004. No operation on April 13, 15, 16, 17, 18, and 20.

Date:	*12 April*	*14 April*	*19 April*	*21 April*	*22 April*	*23 April*	*24 April*	*25 April*	*26 April*	*27 April*	*28 April*	*29 April*
Observation Time-Start:	*10:45*	*11:00*	*10:30*	*11:00*	*10:30*	*10:20*	*7:40*	*7:45*	*8:15*	*7:50*	*7:30*	*9:00*
Observation Time-End:	*15:00*	*15:45*	*15:30*	*17:30*	*17:50*	*18:30*	*19:00*	*19:00*	*19:00*	*17:30*	*17:15*	*16:30*
Military Time (hrs)												
0700 to 0759							195	168		20	37	
0800 to 0859							133	141	191	9	24	
0900 to 0959							84	31	144	117	6	0
1000 to 1059	0		0		25	19	179	14	282	110	2	0
1100 to 1159	0	0	0	0	12	88	381	26	371	283	4	0
1200 to 1259	0	0	0	2	18	426	399	36	376	301	0	1
1300 to 1359	0	1	0	6	28	502	298	204	436	281	3	0
1400 to 1459	0	0	0	7	28	480	321	638	632	126	0	0
1500 to 1559	0	0	0	57	19	809	325	934	521	172	0	0
1600 to 1659				65	7	918	233	916	580	137	0	0
1700 to 1759				56	5	932	403	974	362	150	0	
1800 to 1859				0		245	282	1095	274			
1900 to 1959												
Total	***0***	***1***	***0***	***193***	***142***	***4,419***	***3,233***	***5,177***	***4,169***	***1,706***	***76***	***1***

Date:	*30 April*	*01 May*	*02 May*	*03 May*	*04 May*	*05 May*	*06 May*	*07 May*	*08 May*	*09 May*	*10 May*	*11 May*
Observation Time-Start:	*8:15*	*7:30*	*7:30*	*8:00*	*8:00*	*8:30*	*7:30*	*7:30*	*8:00*	*7:30*	*8:00*	*8:30*
Observation Time-End:	*15:40*	*19:00*	*19:30*	*19:00*	*19:00*	*17:30*	*18:30*	*18:30*	*19:00*	*19:30*	*18:30*	*18:00*
Military Time (hrs)												
0700 to 0759		0	121				10	2		37		
0800 to 0859	0	0	60	284	92	20	34	89	124	125	250	28
0900 to 0959	0	1	636	210	19	41	71	97	39	146	1128	9
1000 to 1059	0	5	1625	511	42	178	78	203	239	343	1730	2
1100 to 1159	0	127	3406	672	49	470	57	410	813	837	1556	0
1200 to 1259	0	329	2093	885	230	712	123	355	1221	852	712	0
1300 to 1359	0	409	1956	662	261	559	144	424	1501	902	647	5
1400 to 1459	0	453	3284	487	272	531	273	401	1143	1206	346	24
1500 to 1559	0	302	3006	392	170	259	134	433	812	1120	323	33
1600 to 1659		360	2634	305	174	134	79	616	401	1102	259	43
1700 to 1759		371	1251	439	27	139	114	286	410	1573	259	65
1800 to 1859		644	692	440	36		69	238	481	1030	134	
1900 to 1959			301							761		
Total	***0***	***3,001***	***21,065***	***5,287***	***1,372***	***3,043***	***1,186***	***3,554***	***7,184***	***10,034***	***7,344***	***209***

Table 3

Continued.

Date:	*12 May*	*13 May*	*14 May*	*15 May*	*16 May*	*17 May*	*18 May*	*19 May*	*20 May*	*21 May*	*22 May*	*23 May*
Observation Time-Start:	*8:00*	*7:30*	*8:00*	*8:00*	*7:30*	*8:00*	*8:00*	*8:00*	*7:30*	*7:30*	*8:00*	*7:30*
Observation Time-End:	*18:30*	*18:30*	*18:15*	*18:30*	*18:30*	*18:00*	*18:30*	*18:00*	*18:00*	*17:00*	*17:45*	*17:00*
Military Time (hrs)												
0700 to 0759		38			24				14	11		4
0800 to 0859	125	68	121	67	56	87	79	26	14	11	35	94
0900 to 0959	604	443	399	111	229	166	107	138	54	8	365	329
1000 to 1059	286	563	493	70	272	105	122	152	160	42	200	419
1100 to 1159	719	807	486	115	208	65	162	186	118	18	90	180
1200 to 1259	529	1003	607	154	405	173	136	187	150	15	71	62
1300 to 1359	702	913	486	222	808	192	170	149	187	6	41	62
1400 to 1459	476	453	338	229	614	149	130	141	119	3	30	10
1500 to 1559	577	173	301	189	552	130	135	101	110	5	29	9
1600 to 1659	453	105	50	95	400	99	194	147	91	14	18	7
1700 to 1759	445	159	265	83	160	105	203	83	87		19	
1800 to 1859	247	96	88	26	109		120					
1900 to 1959												
Total	***5,163***	***4,821***	***3,634***	***1,361***	***3,837***	***1,271***	***1,558***	***1,310***	***1,104***	***133***	***898***	***1,176***

Date:	*24 May*	*25 May*	*26 May*	*27 May*	*28 May*	*29 May*	*30 May*	*31 May*	
Observation Time-Start:	*8:00*	*8:00*	*7:30*	*7:45*	*8:00*	*8:00*	*8:10*	*7:30*	
Observation Time-End:	*16:00*	*16:00*	*16:00*	*16:00*	*16:15*	*16:00*	*16:00*	*14:00*	*Total*
Military Time (hrs)									
0700 to 0759			0	0				0	**681**
0800 to 0859	3	7	8	0	11	1	0	7	**2,424**
0900 to 0959	3	7	9	24	3	12	9	6	**5,805**
1000 to 1059	5	3	4	9	6	3	62	1	**8,564**
1100 to 1159	4	7	19	6	12	4	41	10	**12,819**
1200 to 1259	4	8	20	5	6	1	56	21	**12,684**
1300 to 1359	2	13	18	8	4	3	20	11	**13,246**
1400 to 1459	4	18	20	9	42	1	7		**13,445**
1500 to 1559	3	24	14	9	15	7	15		**12,219**
1600 to 1659					4				**10,640**
1700 to 1759									**9,425**
1800 to 1859									**6,346**
1900 to 1959									**1,062**
Total	***28***	***87***	***112***	***70***	***103***	***32***	***210***	***56***	***109,360***

Table 4

Summary of selected operation and fish catch statistics at the Conowingo Dam East Fish Passage Facility, 1991 to 2004.

Year	Number of Days Operated	Number of Lifts	Operating Time (hrs)	Catch (millions)	Number of Species	American shad	Blueback herring	Alewife	Hickory shad
1991	60	1168	647.2	0.651	42	13,897	13,149	323	0
1992	49	599	454.1	0.492	35	26,040	261	3	0
1993	42	848	463.5	0.53	29	8,203	4,574	0	0
1994	55	955	574.8	1.062	36	26,715	248	5	1
1995	68	986	706.2	1.796	36	46,062	4,004	170	1
1996	49	599	454.1	0.492	35	26,040	261	3	0
1997	64	652	640.0	0.719	36	90,971	242,815	63	0
1998	50	652	640.0	0.713	33	39,904	700	6	0
1999	52	610	467.0	1.184	31	69,712	130,625	14	0
2000	45	570	367.8	0.494	30	153,546	14,963	2	0
2001	43	559	359.8	0.922	30	193,574	284,921	7,458	0
2002	49	560	440.7	0.657	31	108,001	2,037	74	6
2003	44	645	416.6	0.589	25	125,135	530	21	0
2004	**44**	**590**	**390.3**	**0.716**	**30**	**109,360**	**101**	**89**	**0**

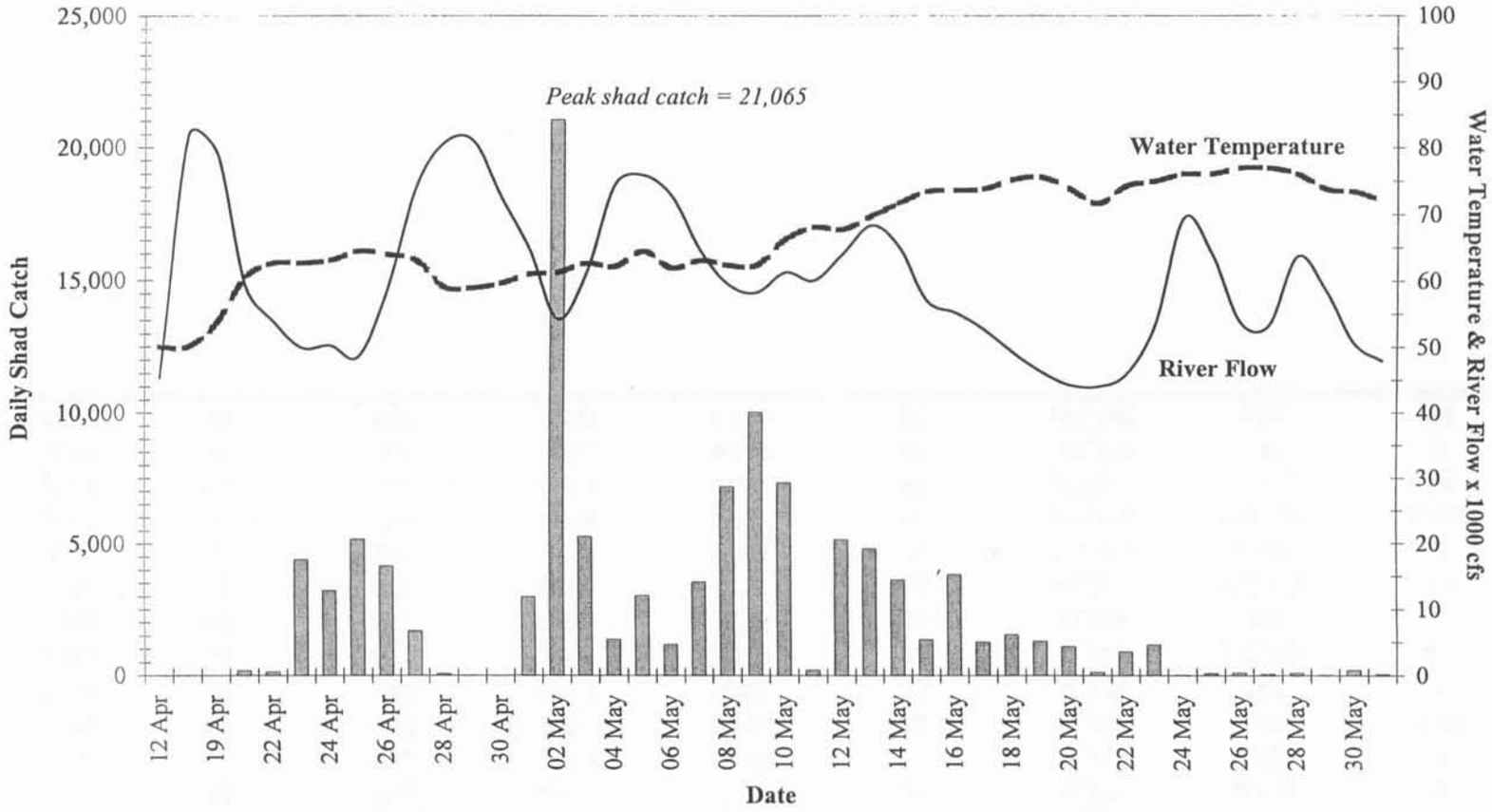

Figure 1

A plot of river flow (x 1000 cfs) as measured at Holtwood Dam and water temperature (°F) in relationship to the daily American shad catch at the Conowingo East Fish Lift, spring 2004. No operation on April 13, 15, 16, 17, 18, and 20.

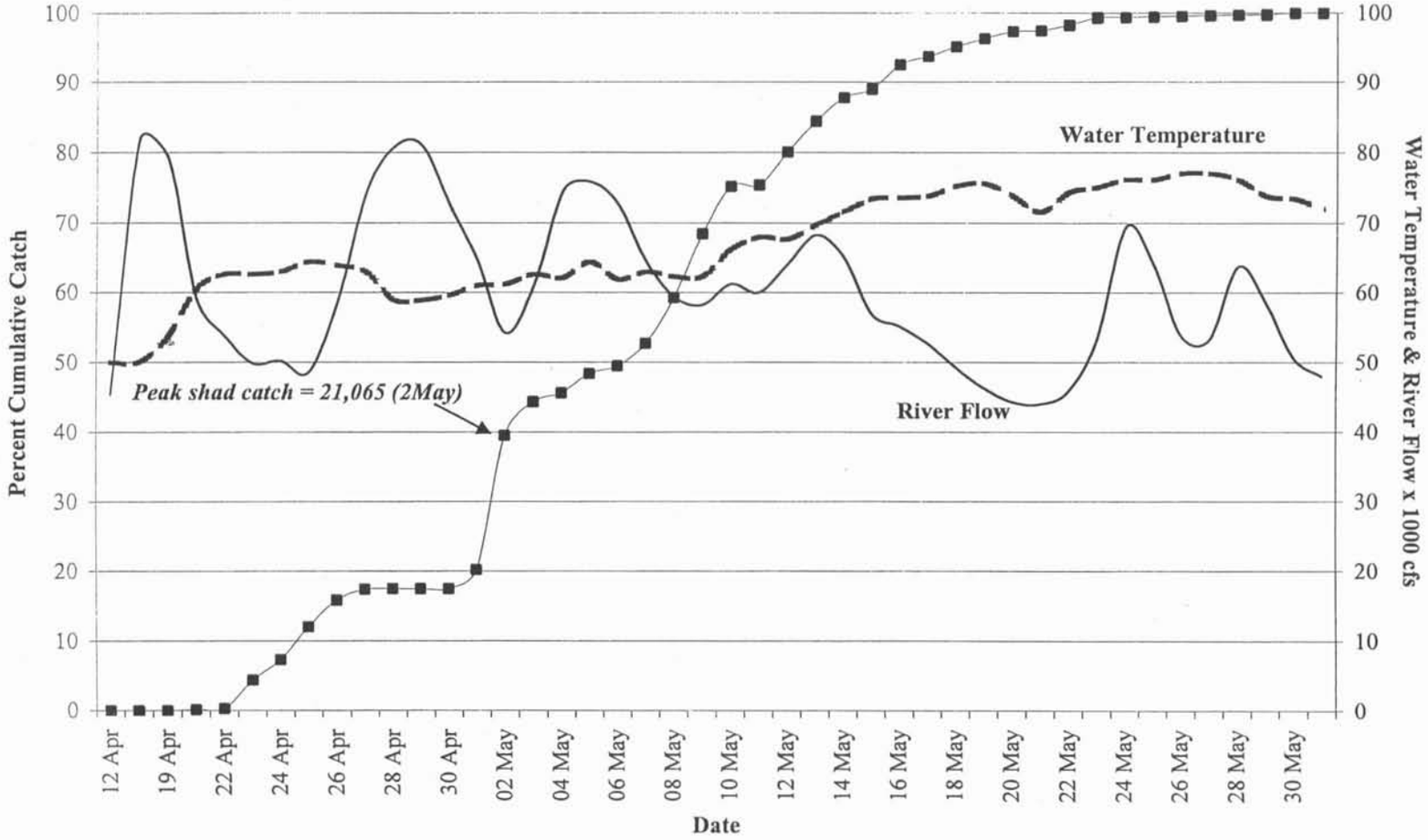

Figure 2

A plot of river flow (x 1000 cfs) as measured at Holtwood Dam and water temperature (°F) in relationship to the percent cumulative American shad catch at the Conowingo East Fish Lift, spring 2004. No operation on April 13, 15, 16, 17, 18, and 20.

Job I - Part 2

SUMMARY OF CONOWINGO DAM WEST FISH LIFT OPERATIONS - 2004

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INTRODUCTION

The shore-based trapping device at Conowingo Dam known as the West fish lift has operated every spring since 1972 for the purpose of collecting and counting American shad, river herring, other migratory species and resident fishes in the tailrace. Since 1985, most shad collected here have been sorted from the daily catch, placed into circular transport tanks, and stocked into suitable spawning waters above the mainstem hydroelectric dams. During the spring runs of 1991 through 1996 the newer East fish lift at Conowingo Dam also served this purpose.

With fish passage available at Holtwood and Safe Harbor dams since 1997, the Conowingo East lift was operated to pass all fish into the project head pond in spring 2004 (see Part 1). Upstream licensees are no longer obligated to pay for trap and transport activities from Conowingo Dam but Susquehanna Electric Company (SECO) has agreed to keep the West lift operational and to administer an annual contract for West lift trapping operations. Project details are coordinated with the resource agencies through the Susquehanna River Technical Committee (SRTC). Funding to reimburse SECO for contractor expenses for these operations, as well as shad tank spawning trials in 2004 was derived from several sources including upstream utility carryover monies from the 1984 settlement agreement, PA Fish and Boat Commission, and Maryland DNR. These contributed funds are administered by the USFWS Susquehanna River Coordinator.

The objectives of Conowingo West lift operations in 2004 included collection and enumeration of shad, river herring, other migratory and resident fishes; provision of live adult shad broodfish to Maryland DNR for tank spawning; and, for on-site tank spawning

and shad egg collection at Conowingo Dam. Shad taken here are also monitored for DNR tags and sex ratios, and scale and head samples are taken for age and otolith analysis. No fish were trucked upstream in 2004.

METHODS

West lift operational procedures adopted by the SRTC included limiting the period of operation to the peak six weeks of the run (late April through the first week in June) and limiting daily lift operations to 8 hours (1100-1900 hrs.). Within these parameters the West lift was operated as in past years, maintaining appropriate entrance velocities and curbing use of adjacent units 1 and 2 whenever river flow dropped below 60,000 cfs. Normandeau Associates, Inc. (NAI) was contracted by SECO to operate both Conowingo fish lifts and to conduct American shad tank spawning trials with egg deliveries to Van Dyke hatchery.

Average daily river flow at Conowingo during the West lift operating period was relatively modest at 40,000-70,000 cfs while water temperature increased steadily from 71 to 77° F. Lift startup operations were delayed until May 13 because of damage to the entrance weirs. Thereafter, the lift operated most days through May 28. Total fishing effort over 14 operating days amounted to 151 lifts and a fishing time of 74.3 hours.

American shad collected in the trap were counted and either placed into holding or spawning tanks. Shad in excess of on-site spawning needs or those sacrificed for biological data were returned alive to the tailrace. Other species were identified, enumerated and returned to the tailrace. No live shad broodfish were provided to Maryland DNR for tank spawning in 2004. Every 50th shad in the West lift collection was sacrificed for otoliths and a scale sample was taken. Lengths and weights were measured, and sex ratios of shad in daily catches were recorded.

RESULTS

Figure 1 shows daily West lift shad catch, river flow and water temperatures for the 2004 season. Total catch at the West lift amounted to 37,589 fish of 30 taxa (Table 1).

Gizzard shad and channel catfish comprised 74% of this total. Alosine catch included 3,426 American shad and only one blueback herring. Catch of American shad averaged 245 per operating day with a single peak day catch of 1,177 fish on May 13. Daily operating parameters and catch by major species is shown in Table 2.

No American shad or river herring were transferred from the West lift in 2004. Normandeau Associates used 1,055 shad at the lift for tank spawning (Job II, Part 3). Of the 163 shad sacrificed for hatchery vs. wild analysis by PFBC, 158 fish produced readable otoliths and 72% were shown to be of hatchery origin. Males averaged 465 mm in total length and 944 g while females averaged 528 mm and 1479 g. A total of 9 Maryland DNR tags were recovered at the West lift including 8 which were hook and line tagged in the tailrace in 2004 and one from 2003. Overall male to female sex ratio of shad in the West lift in 2004 was 1.0 to 1.9 (Table 3).

DISCUSSION

Spring 2004 started relatively cool and rainy but river flows remained modest at 40-81,000 cfs throughout the collection season. In early May, water temperatures increased suddenly from 65 to 73° F in only 5 days. Aside from the peak day on May 13, shad abundance was low with greater than 300 shad being taken on only three dates. As mentioned, most shad collected in 2004 were released alive back to the tailrace.

Although number of lift days and fishing hours was reduced substantially from prior years, West lift catch per effort of about 46 shad per fishing hour, 23 shad per lift, and 245 shad per day were comparable to values measured in recent years (Table 4). Operations and fish catch at the West lift during 1985-2004 are summarized in Table 5.

Table 1

Catch of fishes at the Conowingo Dam West Fish Lift, 2004.

Number of Days	**14**
Number of Lifts	**151**
Fishing Time (hours : minutes)	**74:19:00**
Number of Taxa	**30**
AMERICAN SHAD	3,426
BLUEBACK HERRING	1
GIZZARD SHAD	22,899
STRIPED BASS	458
White Perch	976
American Eel	61
Carp	2,702
Comely Shiner	67
Spotfin Shiner	15
Mimic Shiner	1
Quillback	52
White Sucker	3
Shorthead Redhorse	1
White Catfish	271
Brown Bullhead	1,599
Channel Catfish	4,839
Flathead Catfish	7
Margined Madtom	1
Rock Bass	9
Redbreast Sunfish	70
Green Sunfish	2
Pumpkinseed	3
Bluegill	15
Smallmouth Bass	33
Largemouth Bass	9
White Crappie	1
Black Crappie	1
Yellow Perch	8
Walleye	57
Banded Darter	1
Hybrid Striped Bass	1
Total	**37,589**

Table 2

Daily summary of fishes collected at the Conowingo Dam West Fish Lift, 13-28 May, 2004.

Date:	13 May	14 May	16 May	17 May	18 May	19 May	20 May	21 May
Day:	Thursday	Friday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Number of Lifts:	15	9	7	10	12	11	6	14
Time of First Lift:	8:33	12:20	8:15	9:00	8:30	8:25	11:35	8:00
Time of Last lift:	15:15	15:05	12:12	12:40	14:00	13:30	14:15	14:15
Operating time (hours):	6:42	2:45	3:57	3:40	5:30	5:05	2:40	6:15
Average Water Temperature (°F):	71.0	73.0	74.3	74.8	75.5	75.7	73.6	73.7
American shad	1,177	9	321	254	217	634	74	432
Blueback herring	0	0	0	0	0	0	0	0
Alewife	0	0	0	0	0	0	0	0
Gizzard shad	2,965	2,625	1,050	2,250	1,111	1,890	605	2,475
Hickory shad	0	0	0	0	0	0	0	0
Striped bass	6	10	2	11	5	25	11	93
Carp	3	10	1	373	1,201	17	3	459
Other species	1,011	188	310	338	228	318	341	480
Total	**5,162**	**2,842**	**1,684**	**3,226**	**2,762**	**2,884**	**1,034**	**3,939**

Date:	23 May	24 May	25 May	26 May	27 May	28 May	**TOTAL**
Day:	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	
Number of Lifts:	9	16	13	10	10	9	**151**
Time of First Lift:	8:45	8:15	8:15	8:20	8:15	8:30	
Time of Last lift:	13:50	15:30	15:10	14:35	14:30	14:30	
Operating time (hours):	5:05	7:15	6:55	6:15	6:15	6:00	**74:19:00**
Average Water Temperature (°F):	74.6	75.9	78.7	77.3	77.1	76.7	
American shad	23	237	8	1	21	18	**3,426**
Blueback herring	0	0	0	0	0	1	**1**
Alewife	0	0	0	0	0	0	**0**
Gizzard shad	1,073	2,600	1,515	1,385	530	825	**22,899**
Hickory shad	0	0	0	0	0	0	**0**
Striped bass	9	49	85	53	63	36	**458**
Carp	37	135	370	63	24	6	**2,702**
Other species	246	518	800	1,589	918	818	**8,103**
Total	**1,388**	**3,539**	**2,778**	**3,091**	**1,556**	**1,704**	**37,589**

Table 3

American shad sex ratio information, Conowingo West Fish Lift, 2004. No operation on May 15 and 22.

Date	Sample size	Males	Females	Male:Female Ratio
13 May	134	65	69	1:1.1
14 May	9	6	3	1:0.5
16 May	135	64	71	1:1.1
17 May	122	55	67	1:1.2
18 May	105	35	70	1:2.0
19 May	163	55	108	1:2.0
20 May	74	23	51	1:2.2
21 May	111	20	91	1:4.6
23 May	23	5	18	1:3.6
24 May	142	25	117	1:4.7
25 May	8	1	7	1:7.0
26 May	1	0	1	--
27 May	21	5	16	1:3.2
28 May	18	3	15	1:5.0
Total	**1,066**	**362**	**704**	**1:1.9**

Table 4

Catch and effort of American shad taken at the Conowingo Dam west Fish Lift during primary collection periods,* 1985-2004.

Year	Number Days	Number Lifts	Fishing Hours	Total Catch	Catch Per Day	Catch Per Lift	Catch Per Hour
1985	37	839	328.6	1,518	41	2	4.6
1986	53	737	431.5	5,136	97	7	11.9
1987	49	1,295	506.5	7,659	156	6	15.1
1988	54	1,166	471.7	5,137	95	4	10.9
1989	46	1,034	447.2	8,216	179	8	18.4
1990	62	1,247	541.0	15,958	257	13	29.5
1991	59	1,123	478.5	13,273	225	12	27.7
1992	61	1,517	566.0	10,323	169	7	18.2
1993	41	971	398.0	5,328	130	5	13.4
1994	44	918	414.0	5,595	127	6	13.5
1995	64	1,216	632.2	15,588	244	13	24.7
1996	27	441	245.2	11,458	424	26	46.7
1997	44	611	295.1	12,974	295	21	44.0
1998	26	476	238.6	6,577	253	14	27.6
1999	43	709	312.6	9,658	225	14	30.9
2000	34	424	206.5	9,785	288	23	47.4
2001	41	425	195.1	10,940	267	26	56.1
2002	31	417	147.1	9,347	302	22	63.5
2003	31	367	171.5	9,802	316	27	57.2
2004	**14**	**151**	**74.3**	**3,426**	**245**	**23**	**46.1**

*Only applies to 1985-1995 data. Excludes early and late season catch and effort when less than 10 shad/day were taken.

Table 5

Operations and fish catch at Conowingo West Fish Lift, 1985 to 2004.

Year	Number of Days	Total Fish (Millions)	Number of Taxa	American Shad	Hickory Shad	Alewife	Blueback Herring
1985	55	2.318	41	1,546	9	377	6,763
1986	59	1.831	43	5,195	45	2,822	6,327
1987	60	2.593	43	7,667	35	357	5,861
1988	60	1.602	49	5,169	64	712	14,570
1989	53	1.066	45	8,311	28	1,902	3,611
1990	72	1.188	44	15,964	77	425	9,658
1991	63	0.533	45	13,330	120	2,649	15,616
1992	64	1.560	46	10,335	376	3,344	27,533
1993	45	0.713	37	5,343	0	572	4,052
1994	47	0.564	46	5,615	1	70	2,603
1995	68	0.995	44	15,588	36	5,405	93,859
1996	28	1.233	39	11,473	0	1	871
1997	44	0.346	39	12,974	118	11	133,257
1998	41	0.575	38	6,577	6	31	5,511
1999	43	0.722	34	9,658	32	1,795	8,546
2000	34	0.458	37	9,785	1	9,189	14,326
2001	41	0.310	38	10,940	36	7,824	16,320
2002	31	0.419	35	9,347	0	141	428
2003	31	0.147	30	9,802	1	16	183
2004	14	0.039	30	3,426	0	0	1

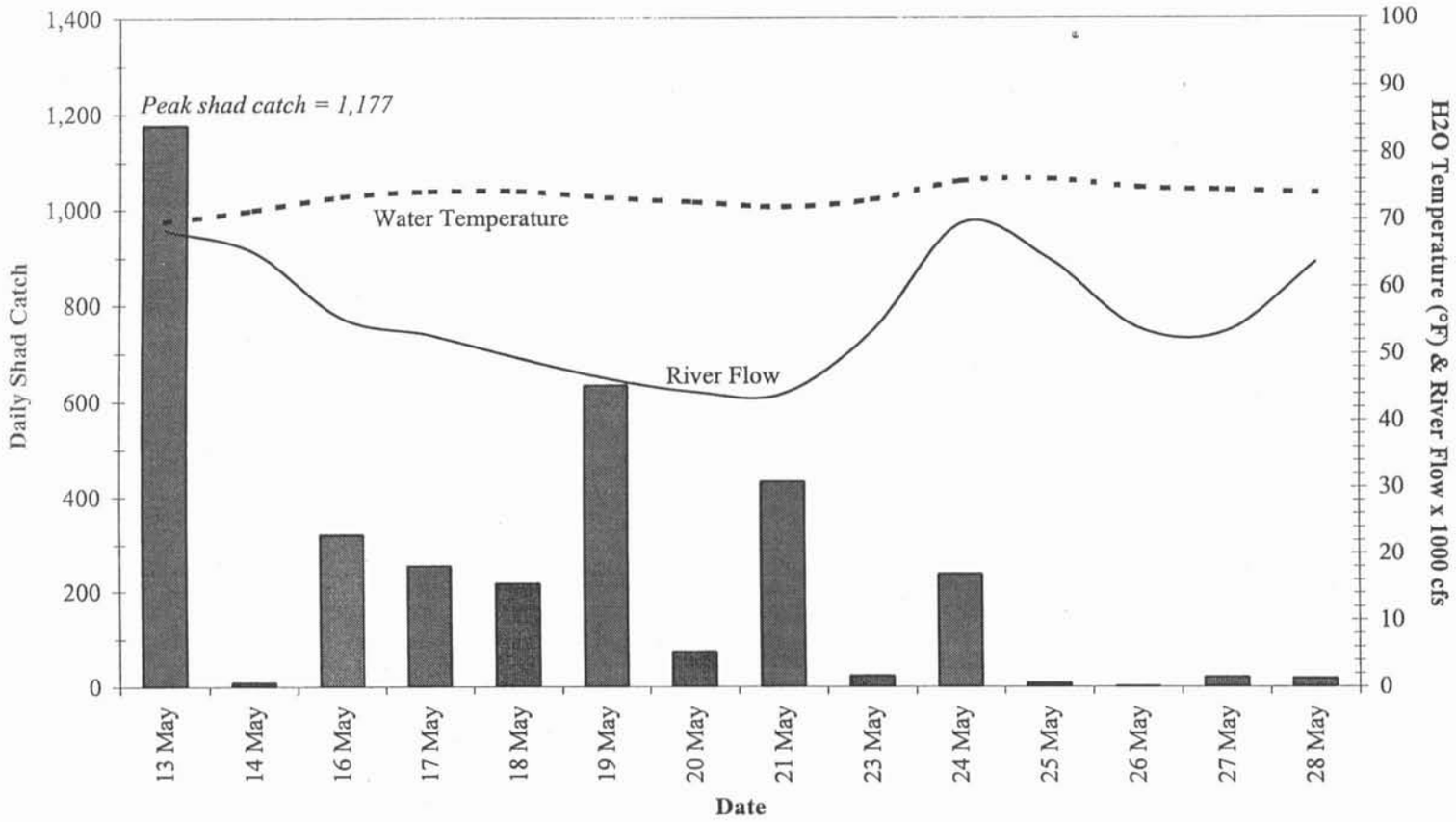

Figure 1

A plot of river **flow (x 1000 cfs) as measured at Holtwood Dam and water temperature (°F) in relation to the daily** American **shad catch at the Conowingo West Fish Lift, spring 2004.**

JOB I – PART 3
SUMMARY OF OPERATIONS AT THE HOLTWOOD DAM FISH PASSAGE FACILITY IN SPRING 2004

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EXECUTIVE SUMMARY

Fishway operations at Holtwood Dam began on 26 April 2004. The tailrace lift was operated for 39 days while the spillway lift operated on 14 days. We terminated lift operations for the season on 3 June. The tailrace and spillway lifts were functional 100% of the time during the 2004 season. We were unable to repair or replace flash boards or install the slick bar prior to or during the season since river flows did not drop to a level conducive to safe working conditions. The lifts passed 177,574 fish of 24 taxa plus one hybrid. Gizzard shad dominated the catch, and comprised nearly 96% of the total fish collected. *Alosa* species captured included 3,428 American shad, and 2 alewife from an in river source.

A total of 3,412 American shad (99.5% of total catch) was passed in the tailrace lift while the spillway lift accounted for only16 American shad (0.5% of total catch). Collection and passage of shad varied daily with 64% of total shad (2,195) passed during three, 3-day periods in May. The highest daily shad catch occurred on 9 May when 428 shad moved upstream during 10 hours of operation. On a daily basis, most shad passed through the fishway between 1200 hrs and 1759 hrs. Fishway operations were conducted at water temperatures ranging from 56.4°F to 76.1°F and river flows between 38,000 and 81,000 cfs. A total of 1,453 American shad, (42% of total), were collected at water temperatures above 70°F, and 798 American shad, (23% of total), were passed when river flows were greater than 65,000 cfs.

In 2004, our fishway evaluation efforts focused on assessing the impact of operation of Units 1 and 2 on the tailrace lift entranceways and American shad catch. An operational matrix was developed and approved by the Holtwood Fish Passage Technical Advisory Committee (HFPTAC) with matrix deployment on 1 May and continuing through to season end. Four operating scenarios were studied: (1) A gate open, Units 1 and 2 off; (2) A gate open, Units 1 and 2 on; (3) B gate open, Units 1 and 2 off; and (4) B gate open, Units 1 and 2 on. Overall, scenario 1, (A gate open, Units 1 and 2 off)

collected the most shad, (916 or 32.5% of total test catch), with scenario 2, (A gate open, Units 1 and 2 on) collecting a similar number of shad, (894 or 31.7% of total test catch). Scenario 4, (B gate open, Units 1 and 2 on), collected the lowest number of shad, (438 or 15.5% of total test catch). Scenario 3, (B gate open, Units 1 and 2 off) accounted for about 20% of the total test catch, (570 shad).

Sustained river flows resulting in spillage every day/all day at Holtwood, coupled with warmer river water temperatures, limited American shad passage this year. Shad numbers were the lowest recorded since fishway start-up in 1997. Future operations will build on the past eight years of operational experience.

INTRODUCTION

On 1 June 1993 representatives of PPL, two other upstream utilities, various state and federal resource agencies, and two sportsmen clubs signed the 1993 Susquehanna River Fish Passage Settlement Agreement. This agreement committed the Holtwood Hydroelectric Project (Holtwood) and the two other upstream hydroelectric projects to provide migratory fish passage at their facilities by the spring of 2000. A major element of this agreement was for PPL, the owner/operator of Holtwood, to construct and place a fishway into operation by 1 April 1997. PPL started construction on the fishway in April 1995, and met the spring 1997 operational target. The upstream facility consisting of a tailrace and spillway lift successfully operated during spring 1997 through spring 2004. This year marked the eighth fish passage effort.

A meeting of the HFPTAC, comprised of PPL, United States Fish and Wildlife Service (USFWS), Maryland Department of Natural Resources (MDDNR), and the Pennsylvania Fish and Boat Commission (PFBC) representatives was held at Holtwood on 29 April 2004. The meeting included discussions of, and a consensus on operation of the fishway during the 2004 spring migration season. Objectives of 2004 upstream fishway operation were (1) monitor passage of migratory and resident fishes through the fishway; (2) assess the impact, (if any), of operation of Units 1 and 2 on the tailrace fishway entranceways; and (3) make visual observations on fish behavior in response to the initiation and cessation of spillway flows during the 2004 season if river conditions permit.

HOLTWOOD OPERATION

Holtwood, built in 1910, is situated on the Susquehanna River at river mile 24 in Lancaster and York counties, Pennsylvania (see figure in Normandeau Associates, Inc. 1998). It is the second upstream hydroelectric facility on the river. The project consists of a concrete gravity overflow dam 2,392 ft long by 55 ft high, a powerhouse with ten turbine units having a combined generating capacity of 107 MW, and a reservoir (Lake Aldred) of 2,400 acres surface area. Each unit is capable of passing approximately 3,000 cfs. Spills occur at the project when river flow or project inflow exceeds the station capacity of approximately 32,000 cfs.

Hydraulic conditions in the spillway at the project are controlled by numerous factors that change hourly, daily and throughout the fishway operating season. The primary factors are river flows, operation of the power station, installation and integrity of the flash boards, operation of four rubber dams installed as part of the fishway project, and operation of the Safe Harbor Hydroelectric Station.

Fishway operations at Holtwood began on 26 April 2004. In spring 2004, river flows greater than station capacity prevented any attempt to repair damaged or missing flashboards and created non-stop spill conditions during the upstream passage season. Damage to rubber dam #2 prevented it from being inflated during fishway operations in 2004.

Fishway Design and Operation

Fishway Design

The Holtwood fishway is sized to pass a design population of 2.7 million American shad and 10 million river herring. The design incorporates numerous criteria established by the USFWS and state resource agencies. Physical design parameters for the fishway are given in Normandeau Associates, Inc. (1998). The fish passage facility at Holtwood is comprised of a tailrace and spillway lift (see figure in Normandeau Associates, Inc. 1998). The tailrace lift has two entrances (gates A and B) and the spillway lift has one entrance (gate C). Each lift has its own fish handling system that includes a mechanically operated crowder, picket screen(s), hopper, and hopper trough gate. Fishes captured in the lifts are sluiced into the trough through which the fish swim into Lake Aldred. Attraction flows in, through, and from the lifts are supplied through a piping system and five diffusers that are gravity fed from two trough intakes. Generally, water conveyance and attraction flow is controlled by regulating the three entrance gates and seven motor-operated valves. Fish that enter the tailrace and/or spillway

entrances are attracted by water flow into the mechanically operated crowder chambers. Once inside, fish are crowded into the hoppers (6,700 gal capacity). Fish are then lifted in the hoppers and sluiced into the trough. Fish swim upstream through the trough past a counting facility and into the forebay through a 14 ft wide fish lift exit gate.

Four inflatable rubber dams, operated from the hydro control room, are an integral component of effective spillway lift operation. During fish lift operations in 2004, three of the four rubber crest dams (#'s 1, 3, and 4) were kept inflated. Flash boards installed in front of the damaged #2 rubber dam during fall 2003 were severely damaged over the winter and could not be replaced prior to or during the season due to river flows that were consistently higher than station capacity.

Design guidelines for fishway operation included three entrance combinations. These were: (1) entrance A, B, and C; (2) entrance A and B; and (3) entrance C. Completion of the attraction water system after the 1997 season resulted in the drafting of operating protocols and guidelines that were flexible and utilized experience gained in the first year of fish lift operation. Following these updated protocols/guidelines, entrances A and B, A, B, and C, or a combination of A and C or B and C were used in 2004.

Fishway Operation

Daily operation of the Holtwood fishway was based on the American shad catch, and managed to maximize that catch. Constant oversight by PPL and Normandeau staff ensured that maintenance activities and mechanical or electrical problems were dealt with immediately to minimize fish lift operational interruptions. Both tailrace and spillway lifts were functional 100% of the time throughout the 2004 season. A maintenance program that included periodic cleaning of the exit channel, nightly inspections, and cleaning of picket screens contributed to this excellent operating performance. Pre-season equipment preparations began in March, and lifts were fully operational on April 1. The catch of shad at Conowingo Dam triggered the start of Holtwood operations on 26 April. We operated the tailrace lift for 39 days during the season while the spillway lift operated on 14 days. River flows ranging from 50,000 cfs to 70,000 cfs on 26 of the 39 days of operation, (66% of the season), may have limited fish passage in spring 2004. Operational hours varied throughout the season in an attempt to maximize the catch of American shad.

Operation of the Holtwood fishway followed methods established during the 1997 and 1998 spring fish migration seasons. A three person staff consisting of a lift supervisor, supervising biologist and biological technician manned the lifts daily. A detailed description of the fishways major components and their operation is found in the 1997 and 1998 summary reports (Normandeau Associates, Inc. 1998 and 1999).

Fish Counts

Fish passing the counting window are identified to species and counted by a biologist or biological technician. The counting area is located immediately downstream of the main attraction water supply area in the trough. 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 and 12 ft long channel on the west side of the trough. The channel is adjacent to a 4 ft by 10 ft window located in the counting room where fish are identified and counted. Passage from the fishway is controlled by two different gates. During the day, fish passage rates are controlled by the technician who opens/closes a set of gates downstream of the viewing window. At night fish are denied passage from the fishway by closing this gate. When necessary, flow is maintained through the exit channel to insure that adequate water quality exists for fish held overnight.

Fish passage data is handled by a single system that records and processes the data. The data (species and numbers passed) is recorded on a worksheet by the biologist or biological technician as fish pass the viewing window. At the end of each hour, fish passage data is entered into a Microsoft Excel spreadsheet on a personal computer and saved. Data processing and reporting is PC-based and accomplished by program scripts, or macros, created within Microsoft Excel spreadsheet software.

At day's end, the data is checked and verified by the biologist or biological technician. After data verification is completed, a daily summary of fish passage is produced and distributed to plant personnel. Each day's data is backed up to a diskette and stored off-site. Daily reports and weekly summaries of fish passage numbers are electronically distributed to members of the Holtwood FPTAC and other cooperators.

RESULTS

Relative Abundance

Table 1 displays the diversity and abundance of fishes collected and passed in the Holtwood fishway during the spring 2004 operational period. A total of 177,574 fish of 24 taxa and one hybrid passed upstream into Lake Aldred. Gizzard shad (170,411) comprised nearly 96% of the fishes passed. American shad numbered 3,428 (1.9% of the total) and represented the second largest portion of the catch. The 2004 American shad passage total was the lowest observed (based on Conowingo results) in the eight years of fish lift operations (Tables 1 and 7). Other abundant fishes passed included carp (1,867), channel catfish (621) and shorthead redhorse (599). The peak one-day passage of all species occurred on 15 May, when 12,683 fish were passed, nearly 96% of which were gizzard shad. Other migratory species collected by the fishway included 2 alewife, (in river source), 3 striped bass, and 1 white perch (Table 1).

American Shad Passage

During three, 3-day periods of operation (2-4 May, 9 and 12-13 May, and 22-24 May), the lifts passed 2,195 of the 3,428 American shad passed overall, representing 64% of the season total. Sustained river flows, (50,000 to 70,000 cfs range), occurred on 23 of the 39 days of operation, (nearly 59% of the time), and appear to have limited fish passage during a large portion of the migratory period. A total of 2,504 American shad were passed with river flows between 50,000 and 70,000 cfs. River flows less than 50,000 cfs occurred on 9 days yielding the passage of 597 American shad. Seven days of operation with river flows greater than 70,000 cfs accounted for the passage of 327 American shad. The fishway collected and passed more than 400 shad on only one day during the entire season (428 shad on 9 May). Fishway operations were conducted at water temperatures ranging from 56.4°F to 76.1°F, and river flows between 38,000 cfs and 81,000 cfs (Table 2 and Figure 1). A total of 1,453 American shad, (42% of total), were collected at water temperatures above 70° F, and 798 American shad, (23% of total), were passed at river flows greater than 65,000 cfs.

The capture of shad at the fishway occurred over a wide range of station operation and discharge conditions (Table 2). Shad were attracted to the tailrace lift at water elevations ranging from 115 ft. to 120 ft. Tailrace elevations typically correspond to unit operation, which varies from 0 to 10 units. During spring 2004, tailrace fishway operation coincided with either eight or ten-turbine operation/generation due to efforts to determine if the tailrace lift catch is impacted by the operation

of Units 1 and 2, (turbines nearest tailrace lift entrance B). The spillway lift operated at spillway elevations of 123 ft to 131 ft. Spillage occurred at all times during fishway operation in spring 2004.

Passage of shad into Lake Aldred occurred at Holtwood forebay elevations ranging from 168 ft to 172.0 ft (Table 2). New flash boards and the slick bar could not be installed before or during the 2004 season since river flows did not drop to a level conducive to safe working conditions. Most of the flash boards adjacent to the spillway fish lift entrance were missing or damaged, thus allowing spillage that directly competed with the attraction water flowing from the spillway lift entrance. Rubber dam #2 has been damaged since spring 2003, but installation of a replacement dam is anticipated prior to spring 2005.

The hourly passage numbers of American shad at Holtwood are provided in Table 3. Most shad, (2,390 or nearly 70% of shad passage total) passed through the fishway between 1200 hrs and 1759 hrs. Generally, shad passage was strongest from 1300 hrs to 1759 hrs, and then declined sharply until operation was ended each evening.

We attempted to qualitatively assess the relative number of shad using the tailrace and spillway lifts by viewing each hopper of fish and estimating the number of shad in each lift as they were sluiced into the trough. We summarized this information by lift, and applied results to the daily shad passage count. We determined the number of shad captured by each lift and/or the percentage of daily passage that was attributable to each lift. Based on this assessment, 3,412 and 16 shad were captured in the tailrace and spillway lifts, respectively, over the total operating period in 2004 (Table 4). Due to river flows that resulted in spillage every day/all day during lift operations, spillway lift operations were limited with very few fish of any species attracted to the spillway lift entrance. At times, spillway flows were observed flowing into the spillway entrance gate, negating attempts to maintain a spillway attraction flow. The spillway lift collected a total of 16 American shad and only on four of the 14 days it was operated.

PASSAGE EVALUATION

In 2004, our fishway evaluation efforts focused on assessing the impact of operation of Units 1 and 2 on the tailrace lift entranceways and American shad catch. An operational matrix was developed and

approved by the HFPTAC with matrix deployment on 1 May and continuing through to season end on 3 June (Table 5). Four operating scenarios were studied: (1) A gate open, Units 1 and 2 off; (2) A gate open, Units 1 and 2 on; (3) B gate open, Units 1 and 2 off; and (4) B gate open, Units 1 and 2 on. Throughout the testing, Valve 4 was set at 60 to 80% open, the crowder tunnel lights were turned on, and the attraction waterfall was also turned on in an attempt to minimize the number of operational variables and maintain testing consistency. The matrix conditions were not adhered to when flows were equal to or greater than 70,000 cfs. Flows of this magnitude occurred on 4, 5, 6, and 24 May.

Table 6 shows the catch/passage results for each test scenario. Overall, scenario 1, (A gate open, Units 1 and 2 off) collected the most shad, (916 or 32.5% of total test catch), with scenario 2, (A gate open, Units 1 and 2 on) collecting a similar number of shad, (894 or 31.7% of total test catch). Scenario 4, (B gate open, Units 1 and 2 on), collected the lowest number of shad, (438 or 15.5% of total test catch). Scenario 3, (B gate open, Units 1 and 2 off) accounted for about 20% of the total test catch, (570 shad).

We present a summary of American shad passage at three river flow ranges in Table 7. As stated in previous reports, low, stable river flows are more conducive to fish passage. In 2004, only the last two days of operation, (2 and 3 June), coincided with river flows less than 40,000 cfs. Basically, every American shad except for two were passed when river flows were greater than 40,000 cfs and about 43% of the shad passed with river flows above 60,000 cfs (Table 7 and Figure 2). Due to the consistency of spillage and damaged sections of flashboards adjacent to the spillway lift, opportunities to operate in between or around spill events were nonexistent. This may account for the lower number of shad passed in 2004 when river flows ranged between 40,000 and 60,000 cfs as compared to the passage values observed in years 2000, 2002, and 2003 for the same river flow range. More American shad were passed in 2004, (1,483), at rivers flows greater than 60,000 cfs than all other years combined for that flow range.

We hope to optimize future fishway operations by utilizing knowledge gained through these observations and modifications. Debugging of the fishway occurred as needed throughout the season, and operation was modified based on conditions encountered on a daily basis. Fish survival in the fishways was excellent; we observed no mortalities.

SUMMARY

In 2004, the Holtwood tailrace fish lift was operated for 39 days while the spillway lift operated on 14 days. The tailrace and spillway lifts were both functional 100% of the time. Fishway systems and equipment functioned as designed and only minor difficulties were encountered. Minor problems resulted from safeguards designed into the electrical and/or mechanical aspects of equipment operation.

A total of 3,428 American shad were passed into Lake Aldred, the lowest total and lowest percentage of shad passed (based on Conowingo passage results) since operations started in 1997 (Table 8). A total of two alewife of in river origin also passed through the fishway. The catch of shad at Conowingo Dam triggered the start of Holtwood operations on 26 April. A total of 3,412 American shad (99.5% of total catch) was passed in the tailrace lift while the spillway lift accounted for only 16 American shad (<1% of total catch). Collection and passage of shad varied daily with 64% of total shad (2,195) passed during three, separate, 3-day periods in May. The highest daily shad catch occurred on 9 May when 428 shad moved upstream in 10 hours of operation. On a daily basis, most shad passed through the fishway between 1200 hrs and 1759 hrs. American shad were collected and passed at water temperatures ranging from 56.4°F to 76.1°F, and river flows between 38,000 and 81,000 cfs.

Preliminary results of the operational matrix test suggest that entrance Gate A is less impacted by the operation of Units 1 and 2 than entrance Gate B. Overall, a total of 1,810 American shad were passed during matrix testing with Gate A open, as compared to 1,008 shad passed when Gate B was utilized. Due to consistent spillage at the Holtwood station in 2004, fewer shad may have been available for capture in the tailrace fish lift. Competing higher flows in the spillway appears to have hampered migration during the entire season. Further evaluation of tailrace conditions with minimal spillage needs to be tested prior to the establishment of any modifications to station or fishway operating schemes.

During spring 2004, gillnet surveys to collect ripe American shad for eggs for the PFBC shad hatchery program, were conducted below the Holtwood project. Locations where Normandeau staff collected American shad are shown in Figure 3. Most American shad collected were green, (not ripe),

and no eggs were obtained. We captured these fish downstream of the Muddy Run project. It appears that during periods of continuous spillage at Holtwood, some portion of the American shad passed at Conowingo hold in areas well below the Holtwood project, making it difficult to attract and pass large numbers of shad during spill events.

A low, stable, river flow appears to be critical for enhancing shad passage rates. The sustained river flows and spillage over Holtwood Dam in spring 2004 made fish passage extremely difficult, but did allow personnel to experiment with various lift component settings that may improve passage rates in upcoming years. Future operations of the fishway will build on the past eight years of operation experience.

RECOMMENDATIONS

1) Operate the fishway at Holtwood Dam under annual operational guidelines developed and approved by the HFPTAC. Fishway operation should adhere to these guidelines; however, personnel must retain the ability to make "on-the-spot" modifications to maximize fishway performance.

2) Continue, as a routine part of fishway operation, a maintenance program that includes periodic scheduled drawdowns and cleaning of the exit channel, nightly inspections of picket screens, and daily checks of hopper doors. Routine maintenance activities minimize disruption of fishway operation.

3) As river flow conditions permit install the "Slick Bar" in front of the fishway exit channel to reduce debris from entering and accumulating at the exit/entrance of the trough. After the "slick bar" is installed implement protocols/guidelines that utilize the hydro control room operator to spill trash by lowering the 10 ft rubber dam. This should be done on an as needed basis prior to the scheduled start of fishway operations.

4) Continue to evaluate the effect of discharge of Units 1 and 2 on the tailrace entranceways during the period of peak shad passage utilizing the test matrix developed prior to the 2004 migration season.

Review fish lift and plant operational records to identify conditions that contribute to spillway lift effectiveness. Prepare spillway lift operational plans to improve effectiveness based on findings.

REFERENCES

Normandeau Associates, Inc. 1998. Summary of operation at the Holtwood Fish Passage Facility in 1997. Report prepared for PPL, Inc., Allentown, PA.

Normandeau Associates, Inc. 1999. Summary of the operation at the Holtwood Fish Passage Facility in 1998. Report prepared for PPL, Inc., Allentown, PA.

Table 1

Summary of the daily number of fish passed by the Holtwood fish passage facility in 2004.

Date:	*26 Apr*	*27 Apr*	*28 Apr*	*29 Apr*	*30 Apr*	*1 May*	*2 May*	*3 May*	*4 May*	*5 May*
Hours of Operation - Tailrace:	*6.2*	*8.4*	*8.0*	*7.4*	*8.6*	*9.5*	*9.6*	*9.2*	*9.3*	*7.6*
Number of Lifts - Tailrace:	*9*	*13*	*12*	*9*	*10*	*11*	*16*	*13*	*11*	*11*
Hours of Operation - Spillway:	*5.0*	*7.7*	*0.0*	*0.0*	*0.0*	*0.0*	*9.0*	*8.6*	*0.0*	*0.0*
Number of Lifts - Spillway:	*8*	*7*	*0*	*0*	*0*	*0*	*8*	*8*	*0*	*0*
Water Temperature (°F):	*62.2*	*58.8*	*56.7*	*56.4*	*58.2*	*60.3*	*62.5*	*64.4*	*62.6*	*61.1*
American shad	122	42	11	4	14	56	176	280	130	50
Alewife	0	0	0	0	0	0	0	0	0	0
Gizzard shad	4,913	3,604	878	1,481	1,748	3,266	5,700	8,170	3,219	1,540
Striped bass	0	0	0	0	0	0	1	0	0	0
Sea lamprey	0	4	0	0	0	0	0	0	1	0
Rainbow trout	1	1	0	0	0	0	2	0	0	0
Brown trout	1	7	0	1	0	0	2	0	0	0
Carp	0	0	0	0	0	2	10	1	4	2
Quillback	1	0	0	0	0	3	8	1	6	0
White sucker	0	13	0	0	0	0	0	0	0	0
Northern hogsucker	0	0	0	0	0	0	0	0	0	0
Shorthead redhorse	3	6	1	1	26	87	151	2	13	19
Channel catfish	23	34	1	0	16	86	38	0	35	3
Yellow bullhead	0	0	0	0	0	0	0	0	0	0
Brown bullhead	0	1	0	0	0	0	0	0	0	0
Flathead catfish	0	2	0	0	0	0	0	0	0	0
White perch	0	0	0	0	0	0	0	0	0	0
Hybrid Striped bass	0	0	0	0	0	0	0	0	0	0
Rock bass	0	0	0	0	0	1	1	0	0	0
Redbreast sunfish	0	2	0	0	0	0	0	0	0	0
Bluegill	0	0	0	0	0	0	0	0	2	3
Smallmouth bass	16	2	1	5	5	6	23	1	23	4
Largemouth bass	0	1	0	0	0	3	3	0	0	0
White crappie	0	0	0	0	0	0	0	0	2	0
Walleye	4	2	1	0	7	11	7	0	24	1
Total	***5,084***	***3,721***	***893***	***1,492***	***1,816***	***3,521***	***6,122***	***8,455***	***3,459***	***1,622***

Table 1

Continued.

Date:	*6 May*	*7 May*	*8 May*	*9 May*	*10 May*	*11 May*	*12 May*	*13 May*	*14 May*	*15 May*
Hours of Operation - Tailrace:	*7.7*	*8.9*	*8.9*	*10.3*	*6.8*	*8.4*	*10.3*	*10.1*	*9.8*	*9.8*
Number of Lifts - Tailrace:	*11*	*13*	*13*	*17*	*11*	*11*	*16*	*16*	*13*	*14*
Hours of Operation - Spillway:	*0.0*	*2.3*	*0.0*	*6.6*	*0.0*	*0.0*	*0.0*	*4.3*	*0.0*	*0.0*
Number of Lifts - Spillway:	*0*	*2*	*0*	*6*	*0*	*0*	*0*	*4*	*0*	*0*
Water ***Temperature (°F):***	*61.3*	*61.7*	*62.5*	*62.8*	*63.9*	*66.3*	*68.9*	*69.6*	*71.3*	*72.3*
American shad	76	33	36	428	13	19	253	232	94	109
Alewife	0	0	0	0	0	0	0	0	0	0
Gizzard shad	2,220	5,432	5,345	7,849	1,870	7,383	8,381	6,243	6,602	12,147
Striped bass	0	0	0	0	0	0	0	0	0	0
Sea lamprey	0	0	0	0	0	0	0	0	0	1
Rainbow trout	1	1	0	0	0	1	0	0	0	0
Brown trout	0	0	0	1	0	0	0	0	0	1
Carp	0	0	5	3	0	0	15	95	81	367
Quillback	0	0	0	2	1	0	6	28	27	3
White sucker	0	0	1	0	0	0	0	0	0	0
Northern hogsucker	0	0	0	0	0	0	0	0	0	0
Shorthead redhorse	67	18	20	90	1	12	26	14	4	5
Channel catfish	13	3	15	26	1	3	5	3	13	39
Yellow bullhead	0	1	0	0	0	0	0	0	0	0
Brown bullhead	0	0	0	0	0	0	0	0	0	0
Flathead catfish	0	0	0	0	0	0	0	0	0	0
White perch	0	0	1	0	0	0	0	0	0	0
Hybrid Striped bass	0	0	0	0	0	0	0	0	0	0
Rock bass	1	1	0	1	0	0	2	0	0	1
Redbreast sunfish	0	0	0	0	0	0	0	0	0	0
Bluegill	0	0	1	0	0	0	0	1	1	0
Smallmouth bass	2	3	2	5	0	15	7	4	5	6
Largemouth bass	0	0	1	1	0	0	0	0	1	0
White crappie	0	0	0	0	0	0	0	0	0	0
Walleye	7	7	2	6	1	2	10	14	9	4
Total	***2,387***	***5,499***	***5,429***	***8,412***	***1,887***	***7,435***	***8,705***	***6,634***	***6,837***	***12,683***

Table 1

Continued.

Date:	*16 May*	*17 May*	*18 May*	*19 May*	*20 May*	*21 May*	*22 May*	*23 May*	*24 May*	*25 May*
Hours of Operation - Tailrace:	*8.9*	*9.9*	*7.0*	*8.8*	*7.8*	*9.2*	*10.4*	*10.3*	*9.4*	*6.8*
Number of Lifts - Tailrace:	*15*	*14*	*9*	*12*	*12*	*15*	*17*	*17*	*17*	*11*
Hours of Operation - Spillway:	*0.0*	*0.0*	*0.0*	*4.3*	*7.7*	*8.5*	*5.4*	*0.0*	*0.0*	*0.0*
Number of Lifts - Spillway:	*0*	*0*	*0*	*4*	*7*	*8*	*5*	*0*	*0*	*0*
Water Temperature (°F):	*73.4*	*74.2*	*74.2*	*73.3*	*72.6*	*71.8*	*71.6*	*72.9*	*75.8*	*76.1*
American shad	53	109	77	51	50	96	310	241	145	34
Alewife	0	0	0	0	0	0	0	0	0	0
Gizzard shad	12,118	6,826	3,900	4,311	8,998	11,044	10,544	5,226	3,893	685
Striped bass	0	0	0	0	0	1	0	0	0	0
Sea lamprey	0	0	0	0	0	1	0	0	0	0
Rainbow trout	0	1	2	1	2	0	0	0	1	1
Brown trout	0	0	0	0	0	0	0	0	0	0
Carp	214	385	20	31	76	24	14	49	419	11
Quillback	4	9	3	17	4	5	0	0	3	8
White sucker	0	0	0	0	0	0	0	0	0	0
Northern hogsucker	0	0	0	0	0	0	0	0	0	0
Shorthead redhorse	3	7	4	2	0	5	1	1	2	2
Channel catfish	16	3	30	3	3	67	11	13	12	30
Yellow bullhead	0	0	0	0	0	0	0	0	0	0
Brown bullhead	0	0	0	0	0	0	0	0	0	0
Flathead catfish	0	0	0	0	0	0	1	0	0	1
White perch	0	0	0	0	0	0	0	0	0	0
Hybrid Striped bass	0	0	0	0	1	0	0	0	0	0
Rock bass	0	0	2	3	2	0	0	0	0	0
Redbreast sunfish	0	0	2	0	0	0	0	0	0	0
Bluegill	1	1	2	0	1	1	0	2	1	2
Smallmouth bass	1	3	8	1	0	4	1	3	2	4
Largemouth bass	0	0	0	0	0	0	1	0	0	1
White crappie	0	0	0	0	0	0	0	0	0	0
Walleye	6	10	18	1	0	6	3	9	18	3
Total	***12,416***	***7,354***	***4,068***	***4,421***	***9,137***	***11,254***	***10,886***	***5,544***	***4,496***	***782***

Table 1

Continued.

Date:	*26 May*	*27 May*	*28 May*	*29 May*	*30 May*	*31 May*	*1 Jun*	*2 Jun*	*3 Jun*	***TOTAL***
Hours of Operation - Tailrace:	*7.8*	*7.4*	*7.6*	*7.5*	*7.0*	*6.7*	*6.7*	*6.7*	*7.0*	***293.6***
Number of Lifts - Tailrace:	*10*	*11*	*12*	*9*	*11*	*12*	*11*	*11*	*11*	***431***
Hours of Operation - Spillway:	*0.0*	*4.6*	*0.0*	*0.0*	*0.0*	*2.2*	*0.0*	*0.0*	*2.2*	***74.0***
Number of Lifts - Spillway:	*0*	*4*	*0*	*0*	*0*	*2*	*0*	*0*	*2*	***71***
Water ***Temperature (°F):***	*74.8*	*74.4*	*74.0*	*73.3*	*71.4*	*70.2*	*69.7*	*69.7*	*70.4*	
American shad	14	32	16	4	5	0	11	2	0	***3,428***
Alewife	0	0	0	0	0	2	0	0	0	***2***
Gizzard shad	770	995	1,309	202	254	168	628	236	313	***170,411***
Striped bass	0	0	1	0	0	0	0	0	0	***3***
Sea lamprey	0	0	0	0	0	0	0	0	0	***7***
Rainbow trout	0	1	0	0	0	0	0	0	0	***16***
Brown trout	0	0	0	0	0	0	0	0	0	***13***
Carp	2	29	2	0	0	0	2	1	3	***1,867***
Quillback	2	9	3	1	1	0	0	0	0	***155***
White sucker	0	0	0	0	0	0	0	0	0	***14***
Northern hogsucker	0	0	0	0	0	0	1	0	0	***1***
Shorthead redhorse	1	1	4	0	0	0	0	0	0	***599***
Channel catfish	4	11	9	13	7	17	4	3	8	***621***
Yellow bullhead	0	0	0	0	0	0	0	0	0	***1***
Brown bullhead	0	0	0	0	0	0	0	0	0	***1***
Flathead catfish	0	0	0	0	0	0	0	0	0	***4***
White perch	0	0	0	0	0	0	0	0	0	***1***
Hybrid Striped bass	0	0	0	0	0	0	0	0	0	***1***
Rock bass	0	0	0	0	0	0	0	0	0	***15***
Redbreast sunfish	0	0	0	0	0	0	0	0	0	***4***
Bluegill	0	1	0	0	0	0	0	0	0	***20***
Smallmouth bass	1	2	1	0	0	0	5	1	0	***172***
Largemouth bass	0	0	0	0	0	0	0	0	0	***12***
White crappie	0	0	0	0	0	0	0	0	0	***2***
Walleye	1	3	1	2	1	0	1	0	2	***204***
Total	***795***	***1,084***	***1,346***	***222***	***268***	***187***	***652***	***243***	***326***	***177,574***

Table 2

Summary of daily average river flow, water temperature, unit operation, fishway weir gate operation, and project water elevations during operation of the Holtwood fish passage facility in 2004.

	River Flow	Water	Secchi	Number	Weir Gate Operation (cfs)			Elevation (ft)		
Date	(cfs)	Temp. (°F)	(in)	Of Units	A	B	C	Tailrace	Spillway	Forebay
26 Apr	58,600	62.2	6	10	150	150	220	119	131	171
26 Apr	58,600	62.2	6	10	150		220	119	131	171
27 Apr	74,200	58.8	4	10	150		220	119	124-129	170
28 Apr	80,800	56.7	2 to 4	10	150	150		120	131	171
29 Apr	81,000	56.4	4 to 6	10	150	150		120	132	171
30 Apr	72,500	58.2	10 to 12	10	150	150		120	128	170-171
*1 May	64,600	60.3	18	10	150			119	127	170
2 May	54,200	62.5	20	10		150	220	119	125	169
3 May	61,100	64.4	18	8	150		220	115	127-130	170
"4 May"	74,500	62.6	18	10	150			118	130	171
"5 May"	75,800	61.1	10	10	150			120	130	171
"6 May"	72,600	61.3	6 to 8	10	150			120	128-130	171
7 May	64,500	61.7	18	8		150	220	116	129	171
7 May	64,500	61.7	18	8		150		116	129	171
8 May	59,400	62.5	18	8		150		117	127	170
9 May	58,200	62.8	20	10	150		220	119	129	170
10 May	61,200	63.9	2 to 4	10		150		120	129	170
11 May	60,000	66.3	12	8	150			118	128	170
12 May	64,000	68.9	18	8	150			117	127-130	171
13 May	68,300	69.6	18	10	150		220	117	129-130	171
13 May	68,300	69.6	18	10	150			120	129-130	171
14 May	65,100	71.3	18	10		150		117	128-132	171
15 May	57,000	72.3	24	8		150		116	127-130	171
16 May	55,200	73.4	18	8		150		116	127-131	170
17 May	52,700	74.2	18	8	150			115	125-131	170
18 May	49,300	74.2	18	10		150		119	127	170

Table 2

Continued.

Date	River Flow (cfs)	Water Temp. (°F)	Secchi (in)	Number Of Units	Weir Gate Operation (cfs)			Elevation (ft)		
					A	B	C	Tailrace	Spillway	Forebay
19 May	46,300	73.3	14 to 18	10	150			119	126	169
19 May	46,300	73.3	14 to 18	10	150			119	126	169
20 May	44,300	72.6	14 to 18	10		150	220	119	125	168-169
21 May	44,000	71.8	16 to 18	10	150		220	119	125.5	169
22 May	45,800	71.6	24	8		150	220	115	125	170
22 May	45,800	71.6	24	8		150		115	128	170
23 May	53,300	72.9	20 to 22	8	150			117	129	171
"24 May"	69,400	75.8	18 to 20	10	150			118	131.5	172
25 May	64,100	76.1	12 to 18	10		150		115	129	171
26 May	53,800	74.8	12 to 14	8	150			115	128	170
27 May	53,300	74.4	12 to 14	10	150		220	119	126	170
28 May	63,700	74.0	8 to 10	8		150		116	132	172
29 May	58,500	73.3	10	10	150			119	128-131	171
30 May	50,500	71.4	10	8	150			116	129	171
31 May	47,900	70.2	8	10		150	220	119	127	169.5
31 May	47,900	70.2	8	10		150		119	127	169.5
1 Jun	44,500	69.7	6 to 8	8		150		117	129	170
2 Jun	38,000	69.7	6 to 8	8		150		116	124-127	169
3 Jun	36,500	70.4	6 to 10	8	150		220	117	123	168
3 Jun	36,500	70.4	6 to 10	8	150			117	123-125	168

* start of tailrace matrix testing.

" " denotes day when matrix was not followed due to river flows >70,000 cfs.

Table 3

Hourly summary of American shad passage at the Holtwood fish passage facility in 2004.

Date:	*26 Apr*	*27 Apr*	*28 Apr*	*29 Apr*	*30 Apr*	*1 May*	*2 May*
Observation Time (Start):	*12:00*	*9:30*	*9:00*	*9:00*	*9:00*	*9:00*	*9:00*
Observation Time (End):	*18:00*	*18:00*	*17:00*	*17:00*	*17:15*	*18:20*	*18:30*
Military Time (hrs)							
0700 to 0759							
0800 to 0859							
0900 to 0959		7	1	0	1	6	10
1000 to 1059		12	1	1	0	1	19
1100 to 1159		3	2	1	0	3	13
1200 to 1259	5	4	1	0	0	1	7
1300 to 1359	10	3	1	0	0	1	19
1400 to 1459	32	1	2	0	1	4	16
1500 to 1559	22	5	3	1	4	14	27
1600 to 1659	29	3	0	1	8	14	27
1700 to 1759	24	4			0	10	17
1800 to 1859						2	21
1900 to 1959							
2000 to 2059							
Total	**122**	**42**	**11**	**4**	**14**	**56**	**176**

Date:	*3 May*	*4 May*	*5 May*	*6 May*	*7 May*	*8 May*	*9 May*
Observation Time (Start):	*9:00*	*9:00*	*9:00*	*9:00*	*9:00*	*9:15*	*8:30*
Observation Time (End):	*18:50*	*18:00*	*17:00*	*17:00*	*17:45*	*18:10*	*18:50*
Military Time (hrs)							
0700 to 0759							
0800 to 0859							2
0900 to 0959	23	17	8	4	11	2	11
1000 to 1059	5	13	6	10	2	5	5
1100 to 1159	8	9	5	15	4	1	3
1200 to 1259	25	18	0	7	1	7	9
1300 to 1359	48	14	2	8	1	4	31
1400 to 1459	44	18	6	5	1	12	111
1500 to 1559	53	23	16	14	1	4	63
1600 to 1659	52	10	7	13	6	1	96
1700 to 1759	17	8			6	0	72
1800 to 1859	5					0	25
1900 to 1959							
2000 to 2059							
Total	**280**	**130**	**50**	**76**	**33**	**36**	**428**

Table 3

Continued.

Date:	*10 May*	*11 May*	*12 May*	*13 May*	*14 May*	*15 May*	*16 May*
Observation Time (Start):	*9:00*	*9:00*	*8:25*	*8:45*	*9:00*	*8:50*	*9:00*
Observation Time (End):	*16:00*	*17:25*	*19:00*	*18:50*	*18:30*	*18:25*	*17:45*
Military Time (hrs)							
0700 to 0759							
0800 to 0859			5	12		0	
0900 to 0959	7	0	11	24	32	11	10
1000 to 1059	0	0	23	20	4	7	7
1100 to 1159	1	0	7	17	12	7	8
1200 to 1259	2	6	17	25	10	12	6
1300 to 1359	0	4	36	18	8	9	10
1400 to 1459	1	2	31	13	3	22	7
1500 to 1559	2	5	17	26	3	23	3
1600 to 1659		2	41	42	14	9	2
1700 to 1759		0	44	23	5	6	0
1800 to 1859			21	12	3	3	
1900 to 1959							
2000 to 2059							
Total	**13**	**19**	**253**	**232**	**94**	**109**	**53**

Date:	*17 May*	*18 May*	*19 May*	*20 May*	*21 May*	*22 May*	*23 May*
Observation Time (Start):	*9:00*	*11:10*	*9:00*	*9:40*	*8:50*	*9:00*	*9:00*
Observation Time (End):	*18:30*	*18:30*	*18:00*	*17:45*	*18:00*	*19:10*	*19:00*
Military Time (hrs)							
0700 to 0759							
0800 to 0859					0		
0900 to 0959	9		13	0	19	21	35
1000 to 1059	16		7	7	3	20	26
1100 to 1159	9	10	8	8	5	51	9
1200 to 1259	23	11	5	4	11	42	32
1300 to 1359	10	13	0	5	4	34	32
1400 to 1459	4	12	3	3	6	22	9
1500 to 1559	13	3	6	6	5	23	16
1600 to 1659	7	7	5	8	20	27	19
1700 to 1759	11	14	4	9	23	23	29
1800 to 1859	7	7				43	34
1900 to 1959						4	
2000 to 2059							
Total	109	77	51	50	96	310	241

Table 3

Continued.

Date:	*24 May*	*25 May*	*26 May*	*27 May*	*28 May*	*29 May*	*30 May*
Observation Time (Start):	*9:00*	*9:00*	*9:00*	*9:00*	*9:00*	*9:00*	*9:00*
Observation Time (End):	*18:20*	*16:00*	*16:30*	*16:20*	*16:00*	*16:15*	*15:45*
Military Time (hrs)							
0700 to 0759							
0800 to 0859							
0900 to 0959	26	13	0	6	4	3	1
1000 to 1059	6	2	3	7	2	1	0
1100 to 1159	6	4	1	4	2	0	1
1200 to 1259	8	5	3	1	4	0	1
1300 to 1359	17	5	3	1	0	0	1
1400 to 1459	26	5	1	5	2	0	0
1500 to 1559	20	0	1	6	2	0	1
1600 to 1659	24		2	2		0	
1700 to 1759	12						
1800 to 1859	0						
1900 to 1959							
2000 to 2059							
Total	**145**	**34**	**14**	**32**	**16**	**4**	**5**

Date:	*31 May*	*1 Jun*	*2 Jun*	*3 Jun*	
Observation Time (Start):	*9:00*	*9:00*	*9:00*	*9:00*	
Observation Time (End):	*15:20*	*15:30*	*15:20*	*15:15*	***Total***
Military Time (hrs)					
0700 to 0759					
0800 to 0859					***19***
0900 to 0959	0	0	0	0	***346***
1000 to 1059	0	3	1	0	***245***
1100 to 1159	0	4	0	0	***241***
1200 to 1259	0	4	1	0	***318***
1300 to 1359	0	0	0	0	***352***
1400 to 1459	0	0	0	0	***430***
1500 to 1559	0	0	0	0	***431***
1600 to 1659					***498***
1700 to 1759					***361***
1800 to 1859					***183***
1900 to 1959					*4*
2000 to 2059					
Total	**0**	**11**	**2**	**0**	***3,428***

Table 4

Visually derived estimate of the American shad catch in the tailrace and spillway lifts at the Holtwood Power Station in 2004.

Date	Shad Catch	Number Collected		Percent Collected	
		Tailrace	Spillway	Tailrace	Spillway
26 Apr	122	122	0	100%	0%
27 Apr	42	42	0	100%	0%
28 Apr	11	11		100%	0%
29 Apr	4	4		100%	0%
30 Apr	14	14		100%	0%
1 May	56	56		100%	0%
2 May	176	175	1	99%	1%
3 May	280	275	5	98%	2%
4 May	130	130		100%	0%
5 May	50	50		100%	0%
6 May	76	76		100%	0%
7 May	33	33	0	100%	0%
8 May	36	36		100%	0%
9 May	428	428	0	100%	0%
10 May	13	13		100%	0%
11 May	19	19		100%	0%
12 May	253	253		100%	0%
13 May	232	232	0	100%	0%
14 May	94	94		100%	0%
15 May	109	109		100%	0%
16 May	53	53		100%	0%
17 May	109	109		100%	0%
18 May	77	77		100%	0%
19 May	51	51	0	100%	0%
20 May	50	45	5	90%	10%
21 May	96	91	5	95%	5%
22 May	310	310	0	100%	0%
23 May	241	241		100%	0%
24 May	145	145		100%	0%
25 May	34	34		100%	0%
26 May	14	14		100%	0%
27 May	32	32	0	100%	0%
28 May	16	16		100%	0%
29 May	4	4		100%	0%
30 May	5	5		100%	0%
31 May	0	0	0	0%	0%
1 Jun	11	11		100%	0%
2 Jun	2	2		100%	0%
3 Jun	0	0	0	0%	0%
Total	***3,428***	***3,412***	***16***	***100%***	***0%***

Table 5

Holtwood test matrix for tailrace fish lift operations in 2004.

Date	Test Day*	Units 1& 2	River Flow (cfs)	Entrance Gate Open	Tunnel Lights	Waterfall	Valve 4	Total Daily Catch	Estimated Daily Tailrace Catch
01 May	1	on	64,600	A	On	On	60-80%	56	56
02 May	2	on	54,200	B	On	On	60-80%	176	175
03 May	3	off	61,100	A	On	On	60-80%	280	275
07 May	4	off	64,500	B	On	On	60-80%	33	33
08 May	5	off	59,400	B	On	On	60-80%	36	36
09 May	6	on	58,200	A	On	On	60-80%	428	428
10 May	7	on	61,200	B	On	On	60-80%	13	13
11 May	8	off	60,000	A	On	On	60-80%	19	19
12 May	9	off	64,000	A	On	On	60-80%	253	253
13 May	10	on	68,300	A	On	On	60-80%	232	232
14 May	11	on	65,100	B	On	On	60-80%	94	94
15 May	12	off	57,000	B	On	On	60-80%	109	109
16 May	13	off	55,200	B	On	On	60-80%	53	53
17 May	14	off	52,700	A	On	On	60-80%	109	109
18 May	15	on	49,300	B	On	On	60-80%	77	77
19 May	16	on	46,300	A	On	On	60-80%	51	51
20 May	17	on	44,300	B	On	On	60-80%	50	45
21 May	18	on	44,000	A	On	On	60-80%	96	91
22 May	19	off	45,800	B	On	On	60-80%	310	310
23 May	20	off	53,300	A	On	On	60-80%	241	241
25 May	21	on	64,100	B	On	On	60-80%	34	34
26 May	22	off	53,800	A	On	On	60-80%	14	14
27 May	23	on	53,300	A	On	On	60-80%	32	32
28 May	24	off	63,700	B	On	On	60-80%	16	16
29 May	25	on	58,500	A	On	On	60-80%	4	4
30 May	26	off	50,500	A	On	On	60-80%	5	5
31 May	27	on	47,900	B	On	On	60-80%	0	0
01 Jun	28	off	44,500	B	On	On	60-80%	11	11
02 Jun	29	off	38,000	B	On	On	60-80%	2	2
03 Jun	30	off	36,500	A	On	On	60-80%	0	0
04 Jun									
05 Jun									

* The Holtwood Matrix will not be followed on days when river flow (as measured at Holtwood) is equal to or greater than 70,000 cfs.

Table 6

Holtwood test matrix results for tailrace fish lift operation in 2004.

Scenario:	**Gate A open;Units 1&2 on**			**Gate A open; Units 1&2 off**			**Gate B open;Units 1&2 on**			**Gate B open;Units 1&2 off**		
	River flow	**Date**	**# Passed**	**River flow**	**Date**	**# Passed**	**River flow**	**Date**	**# Passed**	**River flow**	**Date**	**# Passed**
	64,600	01 May	56	61,100	03 May	275	54,200	02 May	175	64,500	07 May	33
	58,200	09 May	428	60,000	11 May	19	61,200	10 May	13	59,400	08 May	36
	68,300	13 May	232	64,000	12 May	253	65,100	14 May	94	57,000	15 May	109
	46,300	19 May	51	52,700	17 May	109	49,300	18 May	77	55,200	16 May	53
	44,000	21 May	91	53,300	23 May	241	44,300	20 May	45	45,800	22 May	310
	53,300	27 May	32	53,800	26 May	14	64,100	25 May	34	63,700	28 May	16
	58,500	29 May	4	50,500	30 May	5	47,900	31 May	0	44,500	01 Jun	11
				36,500	03 Jun	0				38,000	02 Jun	2
Average river flow	*56,171*			*53,988*			*55,157*			*53,513*		
No. of days		*7*			*8*			*7*			*8*	
Total shad			*894*			*916*			*438*			*570*

Table 7

Holtwood fishway summary table evaluating American shad passage at three river flow ranges.

	1997	1998*	1999	2000*	2001	2002*	2003*	2004*
Migration season start date	18 Apr	27 Apr	25 Apr	06 May	27 Apr	15 Apr	28 Apr	26 Apr
Migration season end date	14 Jun	12 Jun	03 Jun	14 Jun	08 Jun	07 Jun	02 Jun	03 Jun
Season duration (days)	58	47	40	40	43	55	36	39
Number of days of operation	55	41	40	36	42	35	34	39
American shad season total (Conowingo)	90,971	39,904	69,712	153,546	193,574	108,001	125,135	109,360
American shad season total (Holtwood)	28,063	8,235	34,702	29,421	109,976	17,522	25,254	3,428
River flow ≤40,000 cfs								
Number of days	48	22	34	19	40	19	15	2
Percent of season	87%	54%	85%	53%	95%	54%	44%	5%
Number of American shad passed	26,201	7,512	34,069	19,712	109,342	10,322	20,229	2
Daily average of American shad passed	546	341	1,002	1,037	2,733	543	1,348	1
Percent of total passage	93%	91%	98%	67%	99%	59%	80%	0%
River flow 40,001 to 60,000 cfs								
Number of days	7	2	6	12	2	14	18	20
Percent of season	13%	5%	15%	33%	5%	40%	53%	51.30%
Number of American shad passed	1,862	230	633	9,536	634	7,029	5,019	1,943
Daily average of American shad passed	266	115	106	795	317	502	279	97
Percent of Total Passage	7%	3%	2%	32%	1%	40%	19.80%	56.70%
River flow >60,000 cfs								
Number of days	0	17	0	5	0	2	1	17
Percent of season	0%	41%	0%	14%	0%	6%	3%	43.60%
Number of American shad passed	0	493	0	173	0	171	6	1,483
Daily average of American shad passed	0	29	0	35	0	86	6	87
Percent of total passage	0%	6%	0%	1%	0%	1%	0.02%	43.30%

* Denotes seasons of high river flow.

Table 8

Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2004.

	Conowingo East	Holtwood		Safe Harbor		York Haven	
		Number	Passed	Number	Passed	Number	Passed
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%	4,675	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%

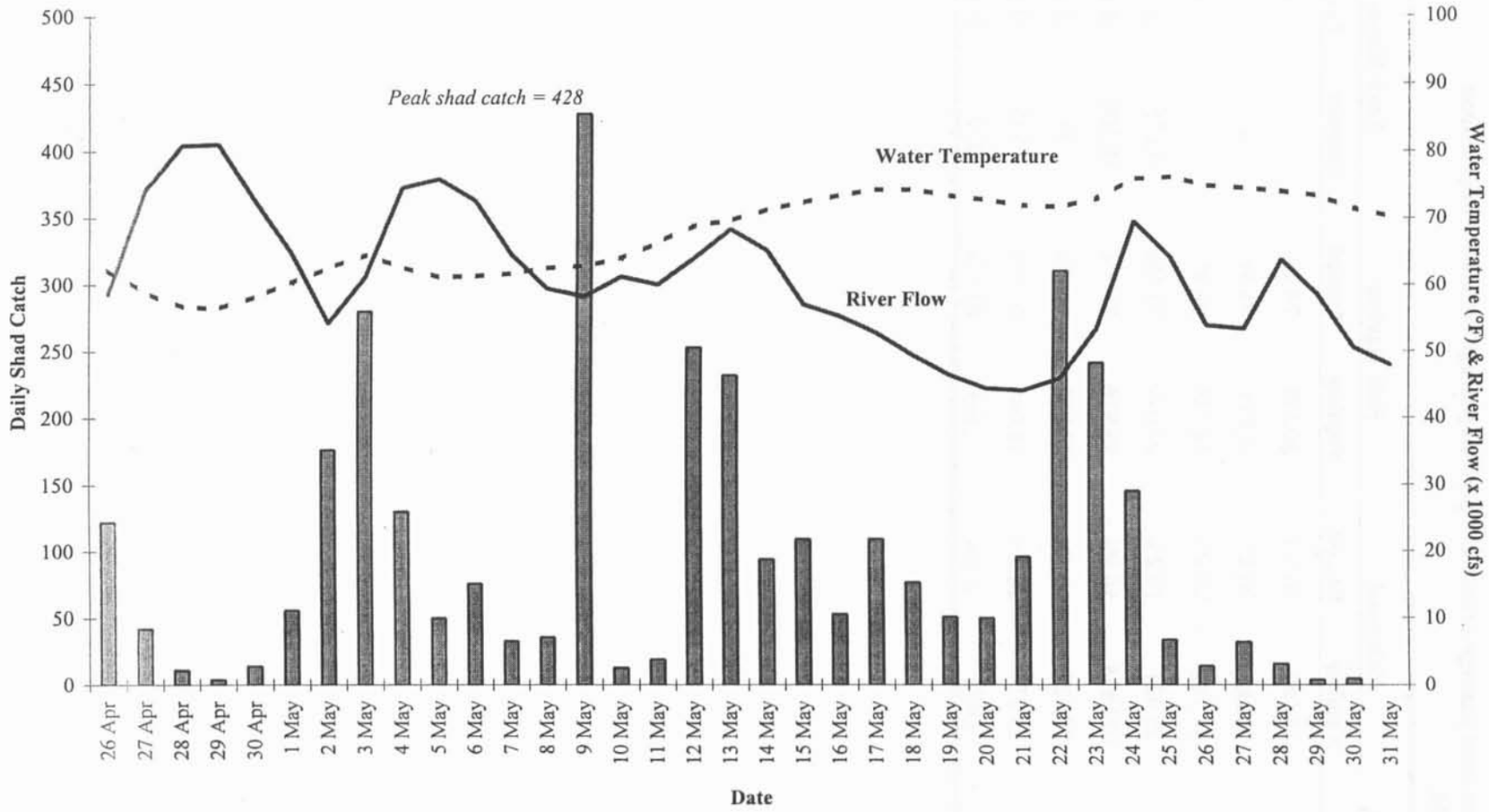

Figure 1

A plot of river flow (x 1000 cfs) and water temperature (°F) in relation to the daily American shad catch at the Holtwood Fish Passage Facility, spring 2004.

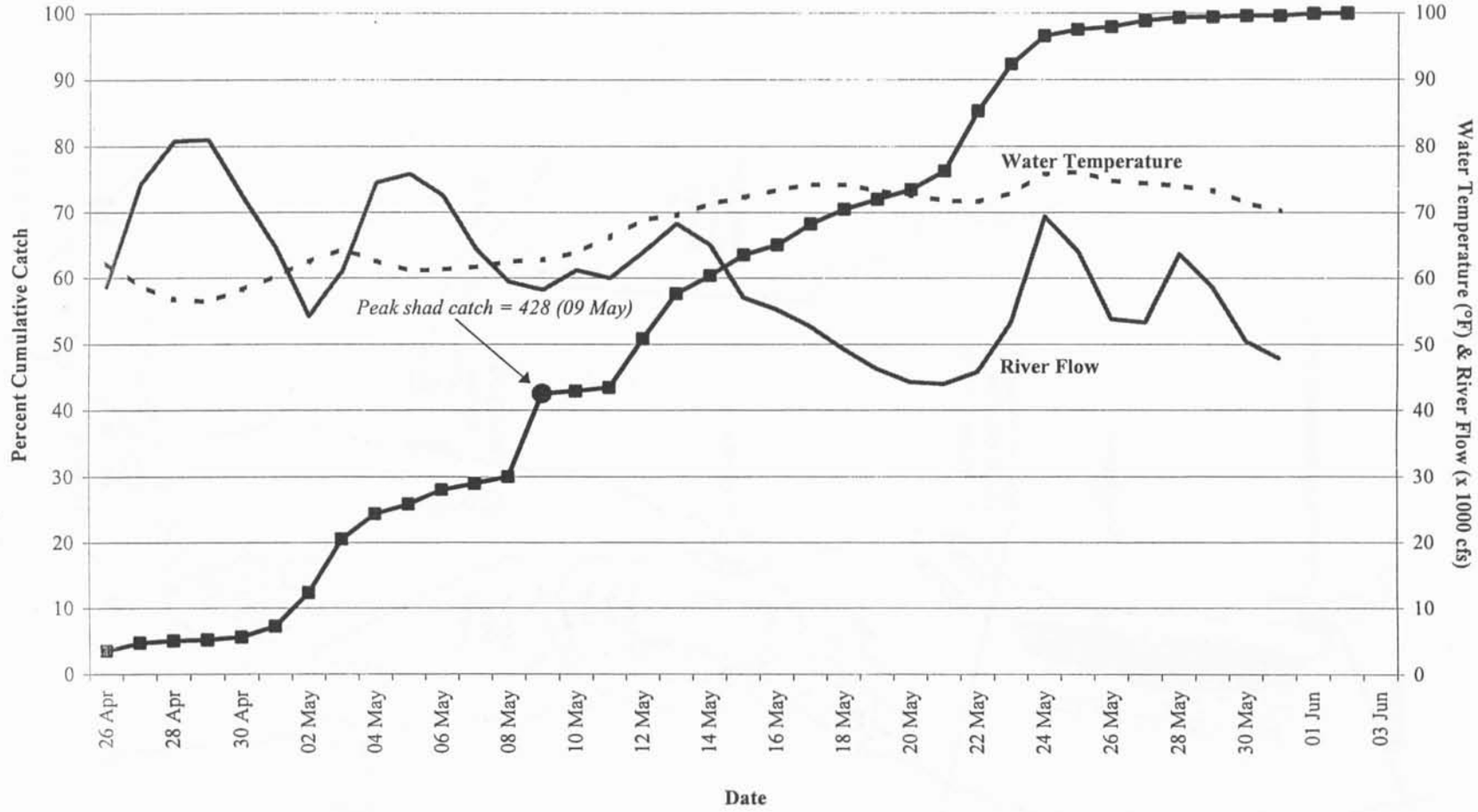

Figure 2

A plot of river flow (x 1000 cfs) and water temperature (°F) in relation to the percent cumulative American shad catch at the Holtwood Fish Passage Facility, spring 2004.

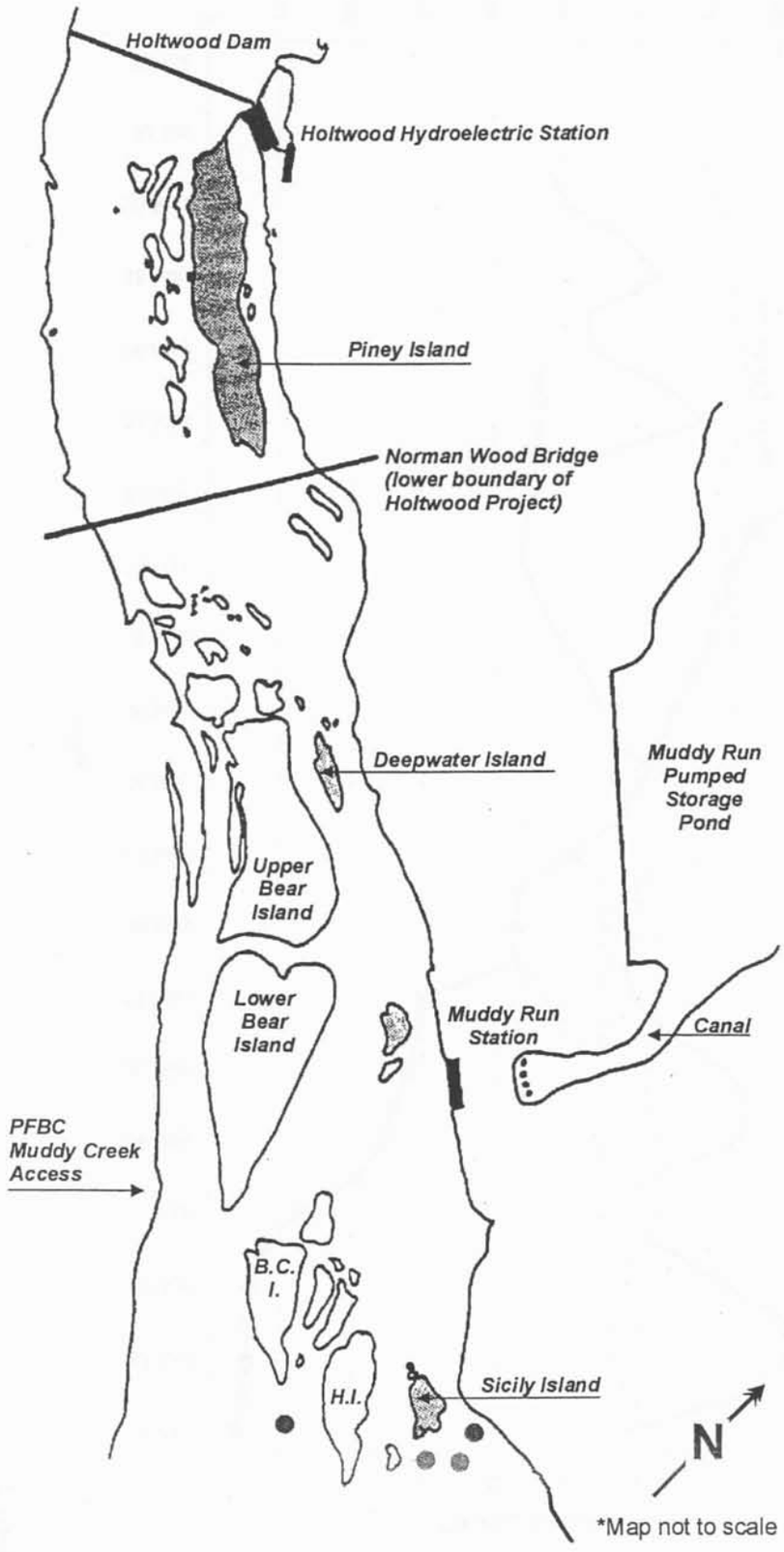

Figure 3. Gill net locations in Conowingo Pond used to collect American shad eggs, May-June 2004.

JOB I – PART 4
SUMMARY OF OPERATIONS AT THE SAFE HARBOR FISH PASSAGE FACILITY - SPRING 2004

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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 2004 operation were to (1) monitor passage of migratory and resident fishes through the fishway; and (2) assess fishway effectiveness.

SAFE HARBOR OPERATION

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.

Fishway Design and Operation

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 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 2004 season utilized a combination of entrances A and C (Table 2).

Fishway Operation

Fishway operation was scheduled to commence after passage of approximately 500 American shad via the Holtwood Fishway, which occurred on 2 May. The Safe Harbor fishway began operation on

3 May and continued through 4 June. Lift operations ended on 4 June due to the dwindling fish catch and rising water temperatures; indications that the migration run was ending.

Throughout the 2004 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.

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 passage from the fishway. Passage from the fishway was controlled by one gate located downstream of the window. Generally, fish passage was controlled by the technician, who opened/closed a set of gates downstream of the viewing window from a controller located in the counting room. Once shad passage increased, fish were denied passage from the fishway by closing the gates downstream of the window each night.

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 distributed in hard copy 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 Safe Harbor Fish Passage Technical Advisory Committee and other cooperators.

RESULTS

Relative Abundance

The relative abundance of fishes collected and passed in 2004 by the Safe Harbor fishway is presented in Table 1. A total of 148,020 fish of 24 species passed upstream into Lake Clarke. Gizzard shad (127,628) was the dominant species passed and comprised nearly 86% of the catch. Some 2,109 American shad were passed upstream through the fishway. Other predominant fishes passed included rock bass (280), smallmouth bass (478), carp (862), walleye (2,123), shorthead redhorse (3,633), channel catfish (5,077), and quillback (5,747). Peak passage occurred on 23 May when 11,995 fish were passed.

American Shad Passage

The Safe Harbor fishway passed 2,109 American shad in 2004 during 33 days of operation (Table 1). Though collection and passage of shad varied daily, numbers were generally lower than in recent years due to sustained spring river flows and fewer American shad passed by the downstream fish passage facilities. Peak shad passage occurred on 13 May when 209 shad were captured and passed in approximately ten hours of operation.

American shad were passed at water temperatures of 61.2°F to 76.1°F and river flows of 34,900 to 75,800 cfs (Table 2 and Figures 1and 2). Water temperature and river flow on those days when more than 100 American shad were passed, averaged 71.3°F (64.4°F to 75.8°F) and 63,600 cfs (53,300 cfs to 69,400 cfs), respectively.

The number of American shad observed passing through the trough by hour is shown in Table 3. Passage rates were generally steady from 0800 to 1559 hr, with a sharp, then steady decrease in catch from 1600 to 1859 hr. A total of 2,024 American shad (96% of total shad passage) passed during the

nine-hour period between 0800 and 1659 hr. The highest hourly passage (85) occurred between 0800 and 0859 hr on 23 May.

During the 2004 season, one American shad tagged downstream of Conowingo dam by the MDDNR, (2002 green tag), was observed at the Safe Harbor fishway.

Alosines

Passage of other alosines, (alewife, blueback herring, and hickory shad), at the Safe Harbor fishway was not observed in 2004. Sustained river flows may have hindered migration efforts of herring since none were observed passing through the Holtwood fish passage facility as well. On 18 May one Alewife was observed, although based on its small size, it is believed that this particular individual was associated with a landlocked stock residing in the Raystown Lake region and not of an anadromous stock.

SUMMARY

The 2004 Safe Harbor fishway operating season was successful; zero operating days were impacted due to mechanical problems. In 33 days, 2109 American shad were passed into Lake Clarke, or nearly 62% of the American shad that were passed into Lake Aldred by the Holtwood fishway (Table 4). Future operations of the fishway will build on the past eight years of experience.

RECOMMENDATIONS

1) Operate the fishway at Safe Harbor Dam per an 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.

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.

Table 1

Number and disposition of fish passed by the Safe Harbor fishway in 2004.

Date:	*03 May*	*04 May*	*05 May*	*06 May*	*07 May*	*08 May*
Hours of Operation:	*8.3*	*9.0*	*4.5*	*8.8*	*8.1*	*8.3*
Start Time:	*8:00*	*8:00*	*11:15*	*7:00*	*7:45*	*8:00*
End Time:	*16:15*	*17:00*	*15:45*	*15:45*	*15:50*	*16:15*
Numbers of Lifts:	*10*	*9*	*4*	*7*	*8*	*7*
Water Temperature (F):	*63.0*	*61.0*	*61.0*	*61.0*	*61.0*	*61.0*
American shad	186	46	22	30	64	48
Alewife	0	0	0	0	0	0
Gizzard shad	3,925	1,830	385	1,336	2,831	3,120
Sea lamprey	0	1	0	1	0	0
Rainbow trout	0	0	0	0	0	0
Brown trout	0	0	0	0	0	0
Carp	58	18	0	2	0	0
Quillback	675	24	1	2	184	263
Shorthead redhorse	355	98	1	8	144	478
Brown bullhead	0	0	0	0	0	0
Yellow bullhead	0	0	0	0	0	0
Channel catfish	83	51	28	7	3	31
Flathead catfish	0	0	0	0	0	0
Rock bass	13	11	1	2	4	2
Redbreast sunfish	0	0	0	0	0	0
Pumpkinseed	0	0	0	0	0	0
Bluegill	1	1	0	0	0	0
Smallmouth bass	66	15	2	6	8	13
Largemouth bass	0	0	0	0	0	0
White crappie	0	0	0	0	0	0
Black crappie	0	0	0	0	0	0
Yellow perch	0	0	6	0	0	0
Walleye	49	44	0	7	35	63
Comely Shiner	0	0	0	0	0	0
Total	***5,411***	***2,139***	***446***	***1,401***	***3,273***	***4,018***

Table 1

Continued.

Date:	*09 May*	*10 May*	*11 May*	*12 May*	*13 May*	*14 May*	*15 May*
Hours of Operation:	*8.3*	*8.6*	*8.6*	*8.9*	*11.2*	*9.8*	*10.1*
Start Time:	*8:00*	*7:30*	*7:15*	*6:50*	*6:35*	*8:00*	*7:50*
End Time:	*16:15*	*16:05*	*15:50*	*15:45*	*17:45*	*17:50*	*17:55*
Numbers of Lifts:	*7*	*8*	*8*	*9*	*12*	*11*	*9*
Water Temperature (F):	*61.0*	*63.0*	*64.0*	*68.0*	*69.0*	*71.0*	*71.0*
American shad	38	73	85	141	209	172	36
Alewife	0	0	0	0	0	0	0
Gizzard shad	3,823	3,460	6,049	8,600	6,425	5,393	8,512
Sea lamprey	0	0	0	0	0	0	0
Rainbow trout	0	0	0	0	0	1	0
Brown trout	0	0	0	2	1	1	0
Carp	1	1	7	150	94	55	22
Quillback	96	81	240	595	474	593	326
Shorthead redhorse	174	68	209	560	602	270	146
Brown bullhead	0	0	0	1	0	0	0
Yellow bullhead	0	0	0	0	0	0	0
Channel catfish	13	29	76	153	347	174	287
Flathead catfish	0	0	0	0	0	0	0
Rock bass	7	3	16	12	29	13	19
Redbreast sunfish	1	0	0	1	0	0	0
Pumpkinseed	0	0	0	0	1	1	0
Bluegill	0	0	1	2	1	0	0
Smallmouth bass	14	5	18	54	49	20	60
Largemouth bass	0	0	0	0	2	0	0
White crappie	0	0	0	0	0	0	0
Black crappie	0	0	0	0	0	0	0
Yellow perch	0	0	0	0	0	0	0
Walleye	40	32	64	140	141	105	253
Comely Shiner	0	0	0	0	12	0	0
Total	***4,207***	***3,752***	***6,765***	***10,411***	***8,375***	***6,798***	***9,661***

Table 1

Continued.

Date:	*16 May*	*17 May*	*18 May*	*19 May*	*20 May*	*21 May*	*22 May*
Hours of Operation:	*10.8*	*7.2*	*9.9*	*11.2*	*10.8*	*10.3*	*10.2*
Start Time:	*6:30*	*10:05*	*7:55*	*7:50*	*6:30*	*6:40*	*6:45*
End Time:	*17:15*	*17:15*	*17:50*	*19:00*	*17:15*	*16:55*	*16:55*
Numbers of Lifts:	*9*	*11*	*13*	*11*	*9*	*9*	*9*
Water Temperature (F):	*71.0*	*74.0*	*73.0*	*72.0*	*72.0*	*72.0*	*71.0*
American shad	75	31	55	30	70	66	64
Alewife	0	0	1	0	0	0	0
Gizzard shad	7,277	8,175	5,656	5,945	4,277	7,266	7,960
Sea lamprey	0	0	0	0	0	0	0
Rainbow trout	0	0	0	0	0	1	0
Brown trout	1	0	0	1	0	0	0
Carp	1	45	29	18	122	36	41
Quillback	612	167	356	266	232	34	51
Shorthead redhorse	165	36	111	13	34	3	3
Brown bullhead	0	0	0	1	1	0	0
Yellow bullhead	0	1	0	0	0	0	0
Channel catfish	299	75	251	318	695	146	155
Flathead catfish	2	0	1	0	0	0	0
Rock bass	51	11	3	7	7	10	22
Redbreast sunfish	0	0	0	0	0	0	1
Pumpkinseed	0	0	1	0	0	2	0
Bluegill	0	3	0	0	0	2	0
Smallmouth bass	27	5	7	11	7	6	3
Largemouth bass	0	3	0	1	0	0	0
White crappie	0	0	0	0	0	0	0
Black crappie	0	0	0	0	1	0	0
Yellow perch	0	0	0	0	1	0	0
Walleye	271	67	52	59	69	68	75
Comely Shiner	0	0	0	0	0	0	0
Total	***8,781***	***8,619***	***6,523***	***6,670***	***5,516***	***7,640***	***8,375***

Table 1

Continued.

Date:	*23 May*	*24 May*	*25 May*	*26 May*	*27 May*	*28 May*	*29 May*
Hours of Operation:	*10.5*	*10.7*	*10.3*	*7.8*	*8.2*	*8.4*	*8.7*
Start Time:	*6:45*	*7:00*	*7:05*	*8:30*	*8:00*	*7:30*	*7:15*
End Time:	*17:15*	*17:40*	*17:25*	*16:15*	*16:10*	*15:55*	*15:55*
Numbers of Lifts:	*9*	*11*	*9*	*7*	*7*	*7*	*8*
Water Temperature (F):	*71.0*	*75.0*	*75.0*	*76.0*	*73.0*	*74.0*	*73.0*
American shad	195	157	99	47	21	19	6
Alewife	0	0	0	0	0	0	0
Gizzard shad	11,022	5,969	4,970	707	785	214	288
Sea lamprey	1	0	0	0	0	0	0
Rainbow trout	0	0	1	1	0	0	0
Brown trout	0	0	0	0	0	0	0
Carp	47	37	25	25	11	2	3
Quillback	126	78	97	111	35	19	1
Shorthead redhorse	0	46	37	54	11	4	0
Brown bullhead	0	1	2	0	0	0	0
Yellow bullhead	0	0	0	0	0	0	0
Channel catfish	254	229	268	634	132	132	56
Flathead catfish	0	0	0	0	0	0	0
Rock bass	20	2	4	5	1	0	2
Redbreast sunfish	2	0	0	1	0	0	1
Pumpkinseed	0	0	0	0	1	0	0
Bluegill	0	2	0	0	2	0	0
Smallmouth bass	63	4	6	3	1	1	0
Largemouth bass	0	0	0	0	0	0	0
White crappie	0	0	0	0	0	0	0
Black crappie	0	0	0	0	0	0	0
Yellow perch	0	0	0	0	0	0	0
Walleye	265	60	32	86	13	3	2
Comely Shiner	0	0	0	0	0	0	0
Total	***11,995***	***6,585***	***5,541***	***1,674***	***1,013***	***394***	***359***

Table 1

Continued.

Date:	*30 May*	*31 May*	*01 Jun*	*02 Jun*	*03 Jun*	*04 Jun*	***Totals***
Hours of Operation:	*11.2*	*9.0*	*7.2*	*7.8*	*3.2*	*8.3*	***285.2***
Start Time:	*8:00*	*8:00*	*9:50*	*8:30*	*8:30*	*8:30*	*--*
End Time:	*19:10*	*17:00*	*17:00*	*16:15*	*11:40*	*16:45*	*--*
Numbers of Lifts:	*6*	*5*	*6*	*6*	*6*	*5*	***265.0***
Water Temperature (F):	*74.0*	*74.0*	*73.0*	*72.0*	*69.0*	*69.0*	*--*
American shad	3	0	7	2	8	4	***2,109***
Alewife	0	0	0	0	0	0	***1***
Gizzard shad	61	39	70	409	453	396	***127,628***
Sea lamprey	0	0	0	0	0	0	***3***
Rainbow trout	0	0	0	0	0	0	***4***
Brown trout	0	0	0	0	0	0	***6***
Carp	0	0	4	1	0	7	***862***
Quillback	0	2	1	0	2	3	***5,747***
Shorthead redhorse	0	0	2	0	0	1	***3,633***
Brown bullhead	0	0	0	0	0	0	***6***
Yellow bullhead	0	0	0	0	0	0	***1***
Channel catfish	48	19	18	4	13	49	***5,077***
Flathead catfish	0	0	0	0	0	0	***3***
Rock bass	1	0	0	0	1	1	***280***
Redbreast sunfish	0	0	0	0	0	0	*7*
Pumpkinseed	0	0	0	0	0	1	*7*
Bluegill	0	0	0	0	0	0	***15***
Smallmouth bass	0	0	0	1	2	1	***478***
Largemouth bass	0	0	1	1	0	0	***8***
White crappie	0	0	0	1	1	0	***2***
Black crappie	0	0	0	0	0	0	***1***
Yellow perch	0	0	0	0	0	0	*7*
Walleye	1	0	2	2	7	16	***2,123***
Comely Shiner	0	0	0	0	0	0	***12***
Total	***114***	***60***	***105***	***421***	***487***	***479***	***148,020***

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 2004.

Date	River Flow[1] (mcfs)	Water Temperature (°F)	Secchi (in)	Maximum Units in Operation	Units Generated	Entrance Gates Utilized	Attraction Flow (cfs)	Tailrace Elevation (ft)	Forebay Elevation (ft)
03 May	61.1	64.4	18	10	1,2,4 to 6,8 to 12	A & C	500	173.3-173.6	225.1-225.5
04 May	74.5	62.6	18	10	1,2,4 to 6,8 to 12	A & C	500	174.0-175.7	224.7-226.5
05 May	75.8	61.2	12	10	1,2,4 to 6,8 to 12	A & C	500	174.7-175.4	225.3-225.5
06 May	72.6	61.3	14	10	1,2,4 to 6,8 to 12	A & C	500	174.2-174.4	226.3-226.7
07 May	64.5	61.7	20	10	1,2,4 to 6,8 to 12	A & C	500	172.9-174.8	225.6-226.5
08 May	59.4	62.5	20	10	3 to 12	A & C	500	173.2-173.5	226.3-226.6
09 May	58.2	62.8	20	11	1,3 to 12	A & C	500	173.9-174.4	225.8-226.4
10 May	61.2	63.9	6	11	1 to 8,10 to 12	A & C	500	174.0-174.1	225.5-226.3
11 May	60.0	66.4	12	11	1 to 8,10 to 12	A & C	500	173.3-174.4	225.9-226.5
12 May	64.0	68.9	18	11	1 to 8,10 to 12	A & C	500	172.7-173.7	225.5-226.1
13 May	68.3	69.6	15	11	1 to 8,10 to 12	A & C	500	174.8-174.9	225.3-226.2
14 May	65.1	71.3	18	12	1 to 12	A & C	500	175.0-175.3	224.5-226.2
15 May	57.0	72.3	18	10	3 to 12	A & C	500	173.4-173.9	225.7-226.4
16 May	55.2	73.4	16	9	3 to 11	A & C	500	172.3-173.2	225.8-226.4
17 May	52.7	74.2	18	10	1,3 to 10,12	A & C	500	172.5-174.7	225.7-226.3
18 May	49.3	74.2	12	10	1 to 10	A & C	500	171.9-173.2	225.6-226.7
19 May	46.3	73.3	14	10	1 to 10	A & C	500	172.2-173.8	225.4-226.2
20 May	44.3	72.6	18	10	1 to 9,12	A & C	500	170.5	226.5
21 May	44.0	71.9	24	10	1 to 8,10,12	A & C	500	170.5-172.8	226.0-226.4
22 May	45.8	71.6	18	8	3 to 7,9,10,12	A & C	500	171.2-173.9	226.0-226.4
23 May	53.3	72.9	18	8	3 to 10	A & C	500	172.6-173.7	226.2-226.6
24 May	69.4	75.8	15	8	3 to 10	A & C	500	174.1-175.8	224.6-226.6
25 May	64.1	76.1	12	10	1 to 9,12	A & C	500	173.1-174.6	225.3-226.2
26 May	53.8	74.8	12	10	1 to 9,12	A & C	500	171.5-174.8	225.6-226.3
27 May	53.3	74.5	12	11	1 to 10,12	A & C	500	171.0-174.0	226.4-227

Table 2

Continued.

Date	River Flow[1] (mcfs)	Water Temperature (°F)	Secchi (in)	Maximum Units in Operation	Units Generated	Entrance Gates Utilized	Attraction Flow (cfs)	Tailrace Elevation (ft)	Forebay Elevation (ft)
28 May	63.7	74.0	11	4	1,2,8,12	A & C	500	171.5-174.3	225.2-227.0
29 May	58.5	73.3	9	10	1,3 to 10,12	A & C	500	172.3-174.2	226.3-226.5
30 May	50.5	71.4	9	9	3 to10,12	A & C	500	170.9-172.2	226.2-226.6
31 May	47.9	70.2	10	10	1,3 to 10,12	A & C	500	171.3-174.1	226.0-226.9
01 Jun	44.5	69.7	10	10	1 to 10	A & C	500	173.1-174.1	225.4-226.3
02 Jun	38.0	69.7	12	9	1 to 7,10,12	A & C	500	171.9-173.7	226.1-226.2
03 Jun	36.5	70.4	12	9	1 to 7,10,12	A & C	500	170.8-171.4	226.0-226.6
04 Jun	34.9	71.0	15	5	2 to 6	A & C	500	168.9-169.9	226.1-226.5

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 2004.

Date:	*03 May*	*04 May*	*05 May*	*06 May*	*07 May*	*08 May*	*09 May*
Observation Time (Start):	*8:00*	*8:00*	*11:15*	*7:00*	*7:45*	*8:00*	*8:00*
Observation Time (End):	*16:15*	*17:00*	*15:45*	*15:45*	*15:50*	*16:15*	*16:15*
Military time (hrs)							
0700 to 0759							
0800 to 0859		6		4	1	8	1
0900 to 0959	33	3		3	7	4	1
1000 to 1059	47	6		3	7	14	8
1100 to 1159	29	2			12	5	3
1200 to 1259	28	3	7	3	8	5	2
1300 to 1359	21	4	3	3	8	5	10
1400 to 1459	12	6	4	12	12	7	8
1500 to 1559	13	12	8	2	9		5
1600 to 1659	3	4					
1700 to 1759							
1800 to 1859							
1900 to 1959							
Total	***186***	***46***	***22***	***30***	***64***	***48***	***38***

Date:	*10 May*	*11 May*	*12 May*	*13 May*	*14 May*	*15 May*	*16 May*
Observation Time (Start):	*7:30*	*7:15*	*6:50*	*6:35*	*8:00*	*7:50*	*6:30*
Observation Time (End):	*16:05*	*15:50*	*15:45*	*17:45*	*17:50*	*17:55*	*17:15*
Military time (hrs)							
0700 to 0759							1
0800 to 0859	9	13	36	56	27		2
0900 to 0959	5	3	11	24	23	5	12
1000 to 1059	13	11	12	12	13	7	13
1100 to 1159	3	4	12	13	25	5	9
1200 to 1259	10	15	21	9	17	1	2
1300 to 1359	11	24	23	13	16	3	8
1400 to 1459	8	6	18	35	18	4	10
1500 to 1559	13	9	8	16	15	2	8
1600 to 1659	1			9	9	5	6
1700 to 1759				22	9	4	4
1800 to 1859							
1900 to 1959							
Total	***73***	***85***	***141***	***209***	***172***	***36***	***75***

Table 3

Continued.

Date:	*17 May*	*18 May*	*19 May*	*20 May*	*21 May*	*22 May*	*23 May*
Observation Time (Start):	*10:05*	*7:55*	*7:50*	*6:30*	*6:40*	*6:45*	*6:45*
Observation Time (End):	*17:15*	*17:50*	*19:00*	*17:15*	*16:55*	*16:55*	*17:15*
Military time (hrs)							
0700 to 0759							
0800 to 0859		12	7	13	13	7	85
0900 to 0959		11	4	9	11	8	21
1000 to 1059		6	7	6	9	6	12
1100 to 1159	2	3	1	11	5	7	9
1200 to 1259	5	5	1	3	3	0	7
1300 to 1359	3	1	4	6	5	0	17
1400 to 1459	6	4	1	2	10	9	13
1500 to 1559	9	9	2	4	6	12	23
1600 to 1659	2	3		11	4	15	3
1700 to 1759	4	1		5			5
1800 to 1859			3				
1900 to 1959							
Total	***31***	***55***	***30***	***70***	***66***	***64***	***195***

Date:	*24 May*	*25 May*	*26 May*	*27 May*	*28 May*	*29 May*	*30 May*
Observation Time (Start):	*7:00*	*7:05*	*8:30*	*8:00*	*7:30*	*7:15*	*8:00*
Observation Time (End):	*17:40*	*17:25*	*16:15*	*16:10*	*15:55*	*15:55*	*19:10*
Military time (hrs)							
0700 to 0759	17						
0800 to 0859	28	36		2	6	3	
0900 to 0959	24	17	8	5			
1000 to 1059	11	11	9	4	3		1
1100 to 1159	4	1	3	3	6		2
1200 to 1259	14	1			1	2	
1300 to 1359	16	8	8	2		1	
1400 to 1459	10	9	7	3	3		
1500 to 1559	16	10	12	2			
1600 to 1659	10	3					
1700 to 1759	7	3					
1800 to 1859							
1900 to 1959							
Total	*157*	*99*	*47*	*21*	*19*	*6*	*3*

Table 3

Continued.

Date:	*31 May*	*01 Jun*	*02 Jun*	*03 Jun*	*04 Jun*	
Observation Time (Start):	*8:00*	*9:50*	*8:30*	*8:30*	*8:30*	
Observation Time (End):	*17:00*	*17:00*	*16:15*	*11:40*	*16:45*	***Total***
Military time (hrs)						
0700 to 0759						18
0800 to 0859				4	2	381
0900 to 0959				2		254
1000 to 1059					1	252
1100 to 1159				1	1	181
1200 to 1259			2	1		176
1300 to 1359		1				224
1400 to 1459		3				240
1500 to 1559		3				228
1600 to 1659						88
1700 to 1759						64
1800 to 1859						3
1900 to 1959						0
Total	***0***	***7***	***2***	***8***	***4***	***2,109***

Table 4

Summary of American shad passage counts and percent passage values at Susquehanna River dams, 1997-2004.

	Conowingo East	Holtwood		Safe Harbor		York Haven	
		Number	Passed	Number	Passed	Number	Passed
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%	4,675	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%

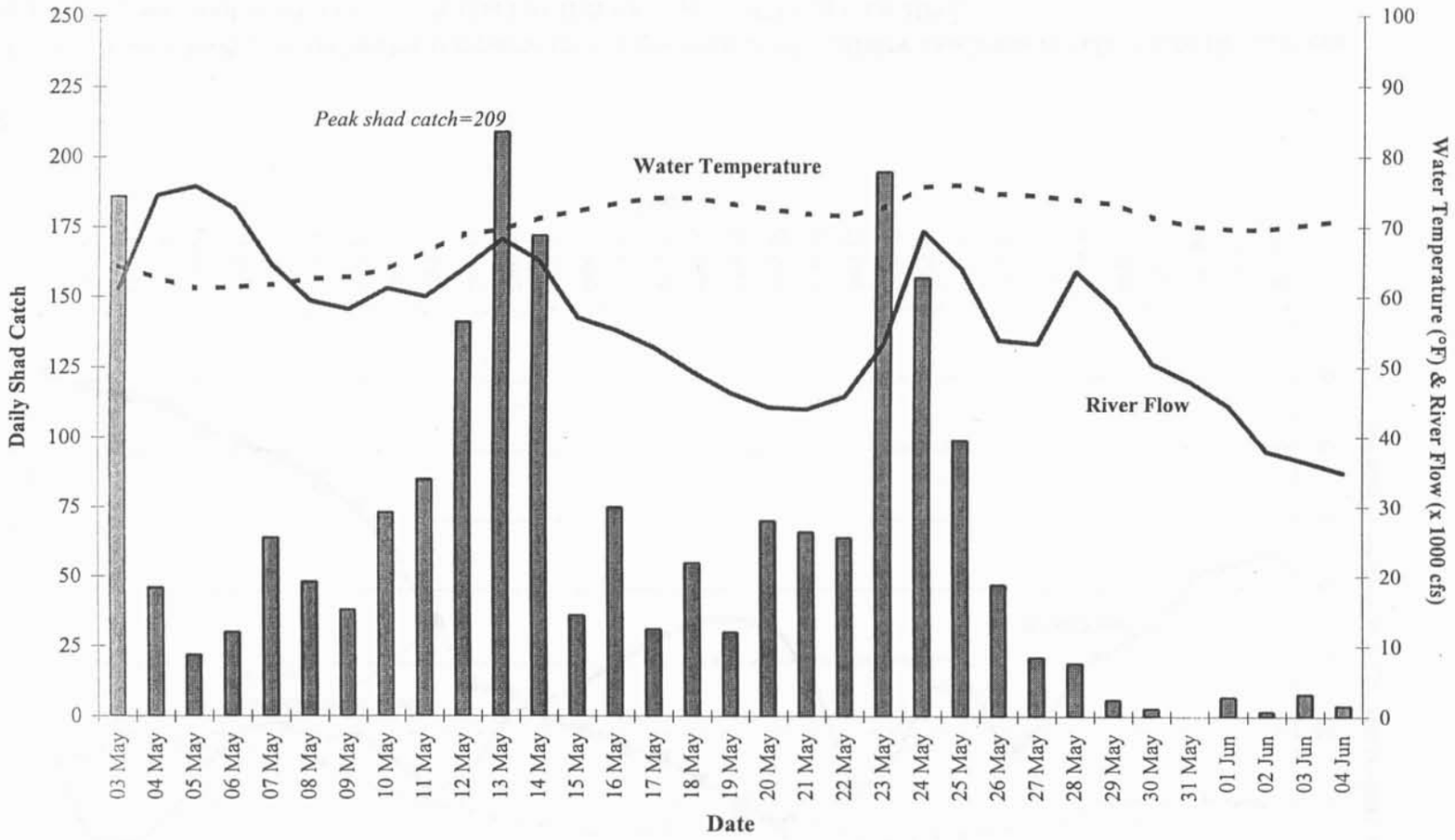

Figure 1

A plot of river flow (x 1000 cfs) and water temperature (°F) as measured at Holtwood Dam in relation to the daily American shad catch at the Safe Harbor fish passage facility, spring 2004.

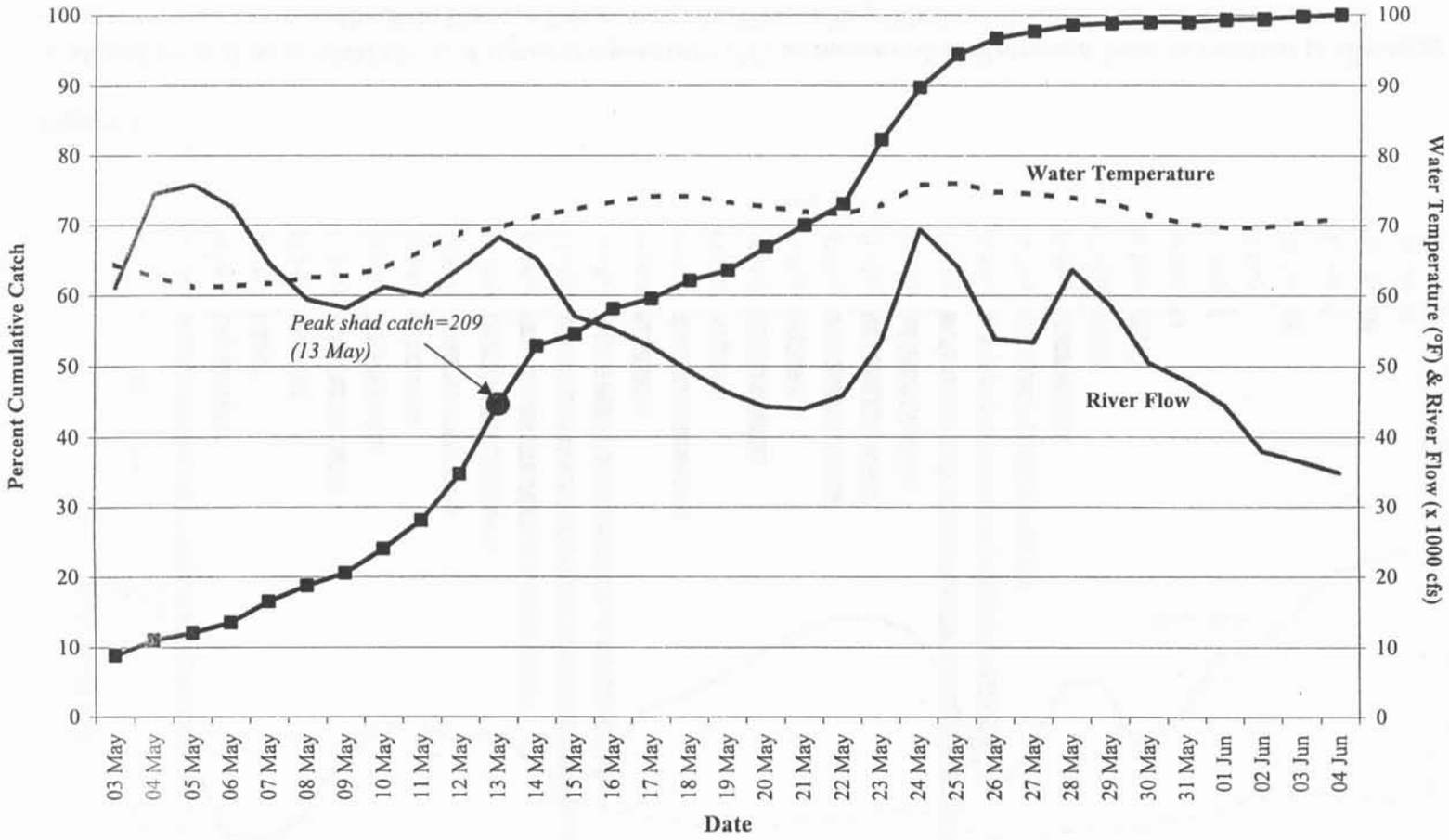

Figure 2

A plot of river flow (x 1000 cfs) and water temperature (°F) as measured at Holtwood Dam in relation to the percent cumulative American shad catch at the Safe Harbor fish passage facility, spring 2004.

FirstEnergy

Job I – Part 5
SUMMARY OF UPSTREAM AND DOWNSTREAM FISH PASSAGE AT THE YORK HAVEN HYDROELECTRIC PROJECT IN 2004

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EXECUTIVE SUMMARY

The Fishway was operated daily for 19 days between 17 May and 4 June before being closed for the season. Increased water temperatures (> 70.0° F) and limited shad passage in June resulted in the decision to close the ladder for the season. A total of 99,973 fish of 18 taxa were enumerated as they passed upstream into Lake Frederic. Gizzard shad (84,243) was the dominant fish species passed and comprised over 84% of the fish passed. A total of 219 American shad passed upstream through the ladder in 2004. Passage of shad varied daily. Some 215 shad passed in May while just 4 shad passed in June.

Peak shad passage occurred on 26 May when 58 shad were passed. American shad were collected and passed at water temperatures of 67.5°F to 75.8°F, river flows of 30,400 cfs to 62,000 cfs and East Channel flows of 3,200 cfs and 8,500 cfs. During the first five days of Fishway operation, 17 to 21 May, 23 shad passed upstream. Peak passage occurred between 22 and 27 May. During this period 167 American shad passed the ladder at water temperatures that varied from 72.0° F to 75.8°F and at river flows that varied from 44,900 cfs to 70,500 cfs. East Channel flows during this period varied from 4,750 cfs to 8,500 cfs. Only 29 shad passed between 28 May and 4 June, the last eight days of Fishway operation.

Passage and survival of fish that utilized the Fishway in 2004 was excellent making the season a success. Operating experience coupled with implementation of recommendations from 2004 and previous seasons should enhance future operation of the Fishway as well as

increase the knowledge and understanding of American shad passage at the York Haven Project.

INTRODUCTION

In 1993, York Haven Power Company (YHPC), the licensees of the Safe Harbor and Holtwood Projects, the U.S. Department of the Interior represented by the Fish and Wildlife Service ("USFWS"), the Susquehanna River Basin Commission ("SRBC"), the states of Maryland and Pennsylvania and their involved agencies – Maryland Department of Natural Resources ("MDNR"), Pennsylvania Fish and Boat Commission ("PFBC") and Pennsylvania Department of Environmental Resources ("PADEP"), and two other parties signed the Susquehanna River Fish Passage Settlement Agreement. This agreement established for each project a Fish Passage Technical Advisory Committee ("FPTAC") comprised of representatives of the affected licensee, USFWS, PFBC and MDNR. Each FPTAC is responsible for reviewing and monitoring the design, construction, maintenance and operation of the fish passage facilities at the respective project, preparing an annual report, and recommending studies and/or modifications to improve upstream and downstream passage.

Following discussions at the January 22, 2004 FPTAC meeting, a consensus was reached on the operation of the York Haven Fishway (Fishway) for the spring migration season. As in 2003, YHPC agreed to make periodic observations for adults in the forebay and would open the trash gate if/when large numbers of adults were observed. They also planned to the implement the juvenile Downstream Passage Protocol that was developed in concert with the FPTAC.

YORK HAVEN FISHWAY OPERATIONS

The installation and operation of the Fishway are part of a cooperative private, state and federal effort to restore American shad (*Alosa sapidissima*) and other migratory fish to the Susquehanna River. In 1997, YHPC and the resource agencies reached a new settlement agreement to revise the type and location of the York Haven fish passage facility. The Fishway is located in Dauphin County, PA at the Three Mile Island end of the East Channel Dam at the York Haven Hydroelectric Project (FERC No. 1888). The Fishway was placed in service by YHPC in April 2000.

Operation in 2004, the fifth year of Fishway operation, was to incorporate experience gained during the first four seasons, along with FPTAC recommendations from the January 22nd meeting. Objectives of 2004 operation were to monitor passage of migratory and resident fishes through the Fishway and continue to assess operation, including improvements to the Fishway and modifications to springtime minimum flow releases. Specific recommendations concerning minimum flows included in the 2004 Fishway Operation Procedure included:

- If/when river flow was less than 23,000 cfs, spill over the Main Dam was to be maintained at a nominal minimum spill of 1,000 cfs during daily Fishway operation.
- If/when low flow conditions occurred, the Station was to reduce Main Dam spill to 4,000 cfs, allowing a temporary staff gauge to be installed in the ponded area immediately downstream of the Fish Passage out fall (Tailrace). A baseline measurement was to be recorded once river conditions stabilized.
- Main Dam spill was to be reduced by an additional 1,000 cfs each day (pending river conditions). Prior to proceeding to the next level of flow reduction a Fish Passage Tailrace level reading needed to be recorded.
- When Main Dam spill reached 1,000 cfs, a final Tailrace level was to be recorded and evaluated prior to continuous operation at this flow condition.
    - A significant reduction in tailrace level could indicate a reduction in the volume of East Channel Flow, which could reduce attraction to the Fishway. Therefore any significant decrease in Tailrace level was to be reviewed with the FPTAC.
    - If a significant reduction was not noted, continuous operation would be permitted for the remainder of the Fish Passage season that occurred during low flow periods.
    - During this low flow operation, spill over the Main Dam was to be reduced to 500 cfs for one day to allow for observation of pooling at the tailrace of the Main Dam.

As in 2003, YHPC indicated that it would attempt to have aerial photographs of the river taken should flow between the Main Dam and the Powerhouse be reduce to 500 cfs. This

assumed there would be no restrictions associated with flying close to TMI and river flows would allow a 500 cfs spill.

Project Operation

The hydroelectric station located in York Haven, PA built in 1904, is situated on the river (river mile 55) in Dauphin and York counties, Pennsylvania (Figure 1). It is the fourth upstream hydroelectric facility on the river. The Project is a 20 unit run-of-river facility capable of producing approximately 19 MW and has an estimated hydraulic capacity of 17,000 cfs. It includes two dams that impound approximately five miles of the river forming Lake Frederic. The Main Dam is approximately 5,000-ft long, with a maximum height of 17-ft. The East Channel Dam is approximately 925-ft long with a maximum height of 9-ft. When river flow exceeds station hydraulic capacity (55% of the year), water is spilled over the two dams.

Fishway Design

Fishway design incorporated numerous criteria established by the USFWS and the other resource agencies. The Fishway has an operating limit of 150,000 cfs river flow (East Channel flow limit of approximately 22,000 cfs). The Fishway includes two sections; a "weir cut" and a vertical notch fish ladder. Figure 2 provides the general arrangement of the Fishway. A detailed description of the Fishway and its major components is located in 2000 and 2001 summary reports (Kleinschmidt 2000 & 2002).

Fishway Operation

All preseason preparations to the Fishway were completed prior to 1 April. The Fishway was opened on 17 May; 2 days after the Safe Harbor Fish Lift passed 1,000 American shad. Fish were counted and allowed to pass upstream daily between 17 May and 4 June; a 19 day period. The Fishway was shutdown for the season on 4 June. The decision to shut the Fishway down for the season was mutually agreed to by members of the FPTAC.

Two people opened the Fishway. First, the attraction flow through the "weir cut" was released by opening both 20-ft wide fixed wheel gates. Next, the downstream entrance gate and the upstream "exit gate" of the ladder were opened. Then the "diffuser gate" was opened. These five gates remained opened the entire season. The entrance gate was the only gate that was adjusted throughout the season. This gate was adjusted manually throughout the season

maintaining a 0.5-ft differential between the surface water elevation downstream of the entrance and the water elevation in the diffuser area of the fish ladder. This setting resulted in an average velocity of 6 ft/sec at the entrance to the ladder. The 7-ft wide stop gate, located between the weir and the fish ladder entrance, remained closed during the entire period of operation.

Excluding the first and last day of operation, which involved opening and closing the Fishway, the Fishway was typically manned by one person. This person, a biologist or technician, adjusted the position of the entrance gate, counted and recorded the number of fish that passed through the ladder hourly, removed debris from the exit of the ladder, made visual observations of fish activity and movement in and through the ladder, and made observations once each day below the Main Dam. This individual also recorded water elevations several times each day on staff gauges located throughout the fishway.

Fish Counts

Fish that passed through the ladder were identified to species and enumerated as they passed the counting window by a biologist or technician. The counting area is located approximately 25-ft upstream of the upper most pool (Figure 2). As fish swim upstream and approach the counting area they are directed by a series of fixed screens to swim up and through a 2-ft wide and 5-ft long channel that is located on the west side of the exit flume. This channel is adjacent to a 4-ft by 8-ft 6-in window located in the counting room through which fish are enumerated. The area in front of the window is illuminated by two 500 watt underwater pool lights that are mounted in the grating that forms the bottom of this channel. Intensity of these lights is rheostat-controlled from inside the counting room enabling the fish counter to set the lights to enhance viewing conditions as needed. Fish passage by the viewing window was controlled by opening or closing an aluminum grating gate with an electric hoist that was controlled from inside the viewing room. This gate was closed nightly between 1600 and 1700 hrs based on shad passage. The stop gate was usually opened each morning the Fishway was manned at 0800 hrs. Occasionally, it was closed for brief periods of time as needed each day to enable the person manning the fishway to conduct other activities. In addition, in an effort to improve viewing, the adjustable crowder screen, modified prior to the start of operation, was adjusted as needed to allow all fish that passed to be observed. Gate settings varied from 6 in to 24 in depending on river conditions.

As in previous seasons, fish passage data was entered on a field data sheet and uploaded into a computer. Files were uploaded each evening, checked and corrected as necessary. Data reporting was PC-based and accomplished by program scripts, or macros, created within Microsoft Excel spreadsheets. Passage data and operational conditions were supplied electronically to YHPC's on-site coordinator/manager and other appropriate YHPC and GPU personnel on a daily basis. In addition, weekly passage information was supplied electronically to YHPC and GPU personnel and members of the FPTAC.

Each day a permanent record (video tape) of daily fish passage was made. The video system was the same system used in 2000 and it was set-up identical to that reported in Kleinschmidt (2000). Fish passage was recorded in 12 hour time-lapse mode. During recording, the recorder imprinted the time and date on each frame of video tape, providing a record for fish that passed the viewing window. No tape review of 2004 passage was conducted, as hourly shad passage never reached the minimum passage requirement of 1,000 shad per hour.

RESULTS

Relative Abundance

The number of fish that passed through the York Haven fish ladder is presented in Table 1. Some 99,973 fish of 18 taxa were enumerated as they passed upstream into Lake Frederic. Gizzard shad (84,234) was the dominant fish species passed and comprised over 84% of the fish passed. Some 219 American shad were counted as they passed through the ladder. Other predominant fishes passed included channel catfish (9,910), quillback (3,066), walleye (1,178), and carp (991). Peak passage occurred on 18 May when some 14,195 fish, or 14.2% of the season total, were passed. Two flathead catfish, a non-indigenous species, were observed passing through the Fishway for the first time since operation began in 2000.

American Shad Passage

A total of 219 American shad passed upstream through the ladder in 2004 (Table 1). Passage of shad varied daily. Some 215 shad passed in May while just 4 shad passed in June. American shad were collected and passed at water temperatures of 67.5° F to 75.8° F, river flows of 30,400 cfs to 62,000 cfs and East Channel flows of 3,200 cfs and 8,500 cfs (Tables 2 and 3, Figures 3 and 4). During the first five days of Fishway operation, 17 to 21 May, 23 shad passed upstream. Peak passage occurred between 22 and 27 May. During this period 167 American shad passed the ladder at water temperatures that varied from 72.0° F to 75.8° F and

at river flows that varied from 44,900 cfs to 70,500 cfs. East Channel flows during this period varied from 4,750 cfs to 8,500 cfs. Only 29 shad passed between 28 May and 4 June, the last eight days of Fishway operation.

The hourly passage of American shad through the fish ladder is given in Table 3. Generally, daily shad passage was similar between 0800 hrs and 1300 hrs. Passage increased slightly between 1301 hrs and 1400 hrs before declining during the last several hours of viewing. Peak hourly passage of shad (14) occurred on 25 May between 1301 hrs and 1400 hrs. Over 70% of the shad passed prior to 1300 hours; during this period total hourly passage varied from 28 to 34 shad. Forty shad passed from 1301 hrs to 1400 hrs. A total of 24 shad passed between 1401 hrs and 1700 hrs; 17 and 7 shad passed between 1401 and 1500 hrs and 1501 hrs and 1600 hrs, respectively. No shad passed between 1601 hrs and 1700 hrs.

Other Alosines and Observations

Although no other alosids (alewife, blueback herring and hickory shad) were observed passing through the ladder two striped bass did pass through the ladder (Table 1).

Once each day visual observations of fish activity were made on a random basis below the Main Dam. On several occasions several carp, quillback and gizzard shad were observed trying to swim over the Main Dam. No shad or other alosids were observed below the Main Dam. Although it was not anticipated that American shad would be able to pass though the "weir cut" due to high velocities, observations were made several times each day in an attempt to see if American shad or other fishes passed upstream through this portion of the Fishway. No fish were observed passing through this portion of the Fishway.

SUMMARY

The spring 2004 York Haven Fishway operating season was considered a success. Survival of fish that utilized the Fishway was considered excellent as no mortalities were observed. Some 219 American shad passed upstream through the Fishway. Although the impact high river flows had on upstream movement of shad in the river in 2004 is unknown, it is likely this factor that resulted in reduced passage at the three downstream dam fishways and contributed to reduced passage at York Haven.

Combining proposed recommendations with operating experience gained since 2000 will enable all those involved with the Susquehanna River Shad Restoration partnership to gain a better understanding of fish passage at the York Haven Project.

RECOMMENDATIONS FOR 2005 OPERATION

As River flows were high again this season, YHPC plans to:

1. Continue working with the FPTAC over the next several seasons to determine the minimum spill at the Main Dam and the attraction flow in the East Channel necessary to optimize fish passage and generation at the Project; and,
2. Continue the collection and evaluation of seasonal passage statistics evaluating fishway effectiveness.

DOWNSTREAM FISH PASSAGE

As in 2003, YHPC agreed to make periodic observations for adults in the forebay and open the trash gate if/when large numbers of adults were observed. They also planned to implement the juvenile Downstream Passage Protocol that was developed in concert with the FPTAC.

Adult Passage

Station Personnel made periodic observations of the forebay area from June through July, 2004. As limited numbers of prespawned shad passed upstream no observations of post-spawned adult shad were noted. This observation process will continue in 2005.

Juvenile Passage

The Juvenile Downstream Passage Protocol provides for:

- Monitoring the forebay to determine when outmigrating juveniles arrive at the project
- Starting "Downstream Operation" when juveniles arrive at York Haven; Downstream Operation begins each evening at sunset and continue until about 11:30 p.m. Downstream Operation includes:
    - Turning on temporary lighting at the trash sluiceway and opening the sluiceway
    - Operating only Units 1-6 when river flow is insufficient for operation of any of the remaining units

- Operating Units 7-20 only when river flow exceeds the hydraulic capacity of available Units 1-6; the operating priority for Units 7-20 is Unit 7, Unit 8, Unit 9 etc.

- Monitoring and sampling in the forebay as river water temperatures drop and/or river flows increase to determine when the juvenile shad emigration has ended for the season

- Ceasing "Downstream Operation" at the end of the run, in consultation with members of the FPTAC.

Since observations of juvenile shad and other clupeids were non-existent in the York Haven forebay during the fall of 2004 "Downstream Operation" was not implemented. In accordance with the protocol, monitoring of the York Haven forebay for the presence of fish began in early September and continued through September. Throughout the period, detection of fish activity was generally non-existent and/or extremely light by station personnel that monitored the forebay nightly for fish activity.

According to the USGS, September had the highest flow reported for the month since they began keeping records in 1937. During September, the remnants of three hurricanes moved through the Susquehanna Valley resulting in river flows that varied from 16,000 cfs to 929,000 cfs; flow exceeded 100,000 cfs on 12 days between 11 and 30 September (Figure 5). As no juvenile shad were observed it was apparent that any juvenile shad that had used the nursery habitat upstream of the Project had passed downstream undetected. Although unsubstantiated, it is highly likely that the downstream movement of juvenile shad occurred quickly during one and/or all three high flow events. In addition, it is likely that natural reproduction was limited by low numbers of shad passed upstream and high flows throughout the season.

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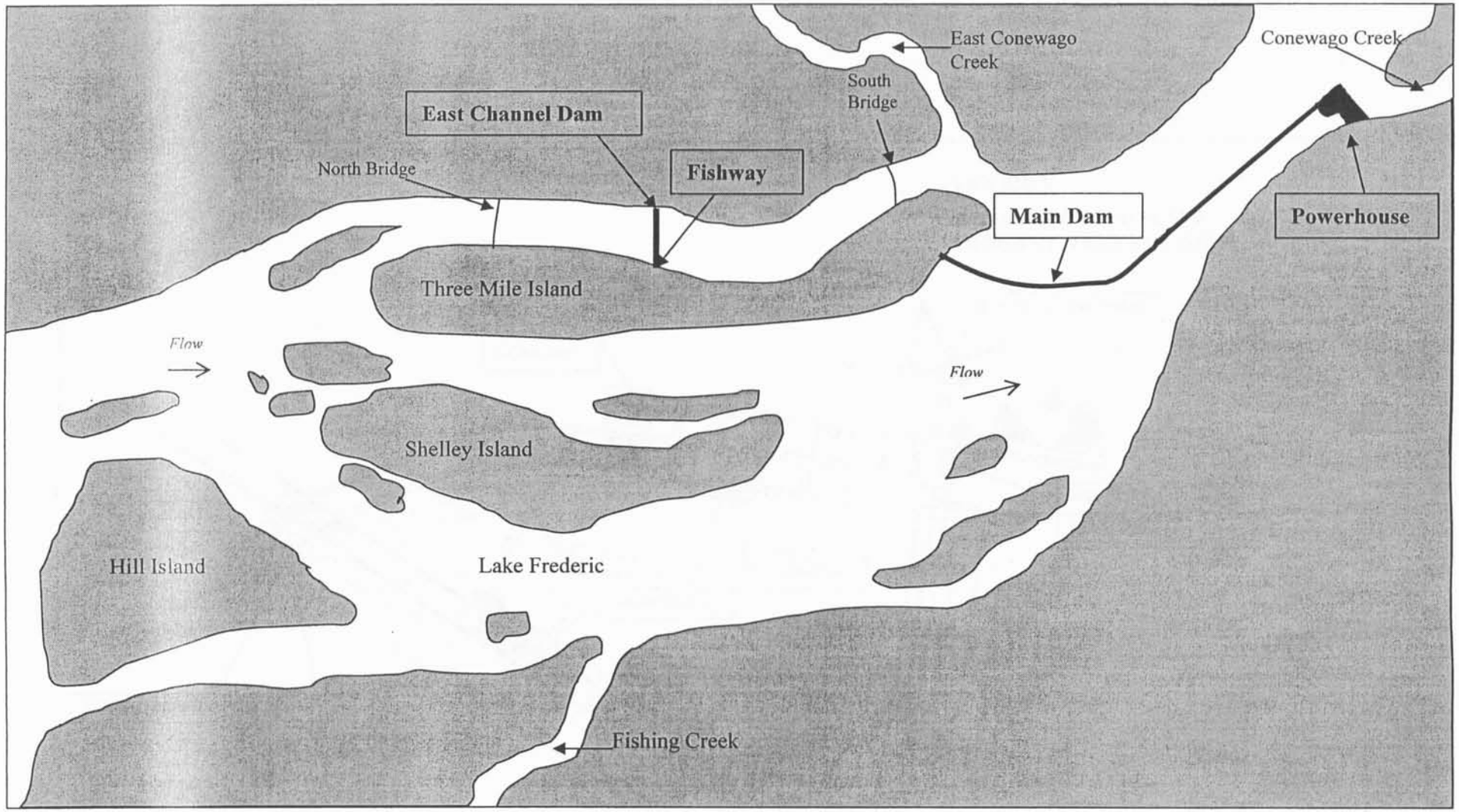
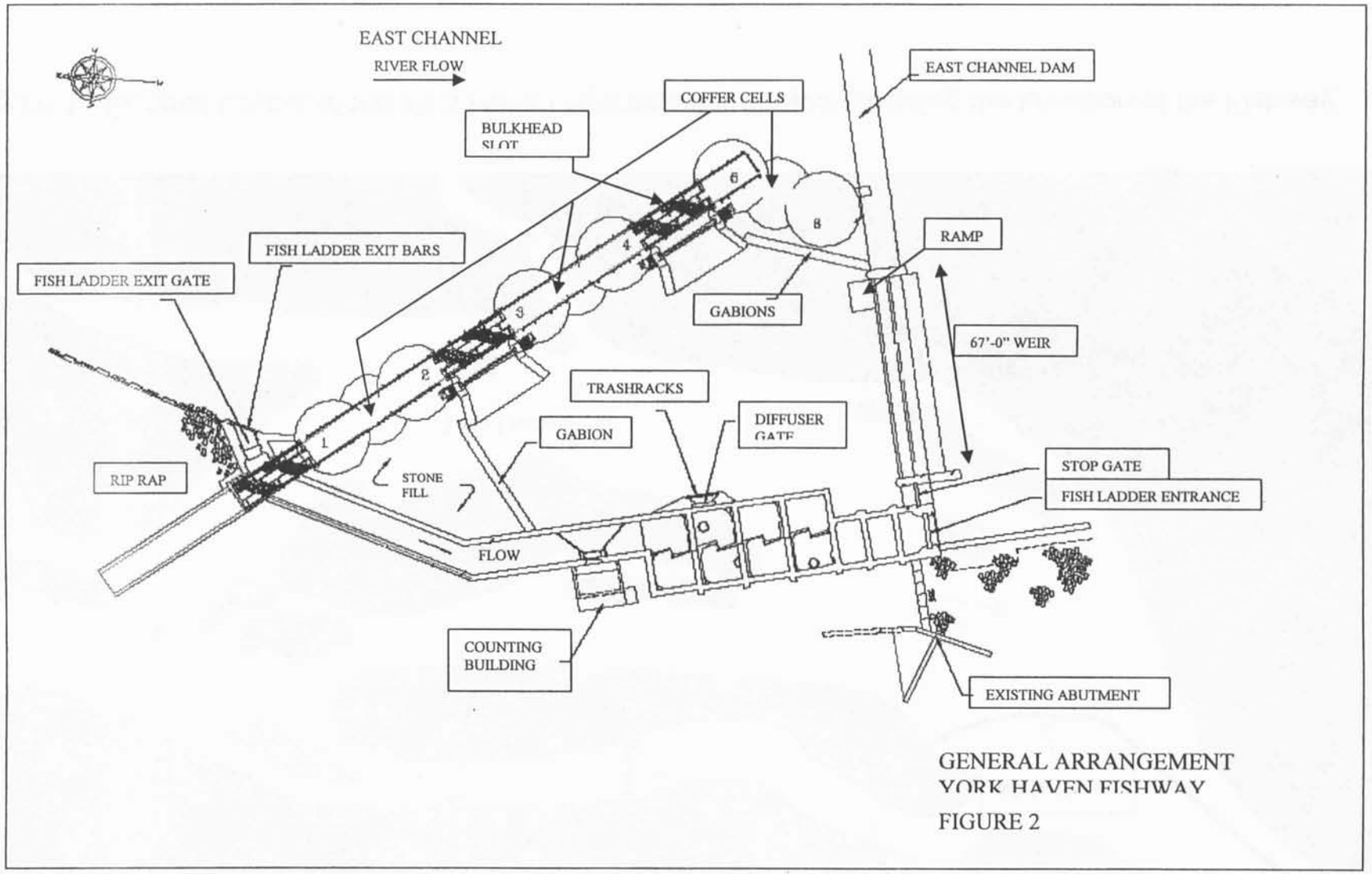


Figure 1. General Layout of the York Haven Hydroelectric Project Showing the Location of the Fishway.



GENERAL ARRANGEMENT
YORK HAVEN FISHWAY
FIGURE 2

Figure 3. Plot of River Flow (x 1000 cfs) & Water Temperature (F) in Relation to the Daily American Shad Passage at the York Haven Fishway in Spring 2004

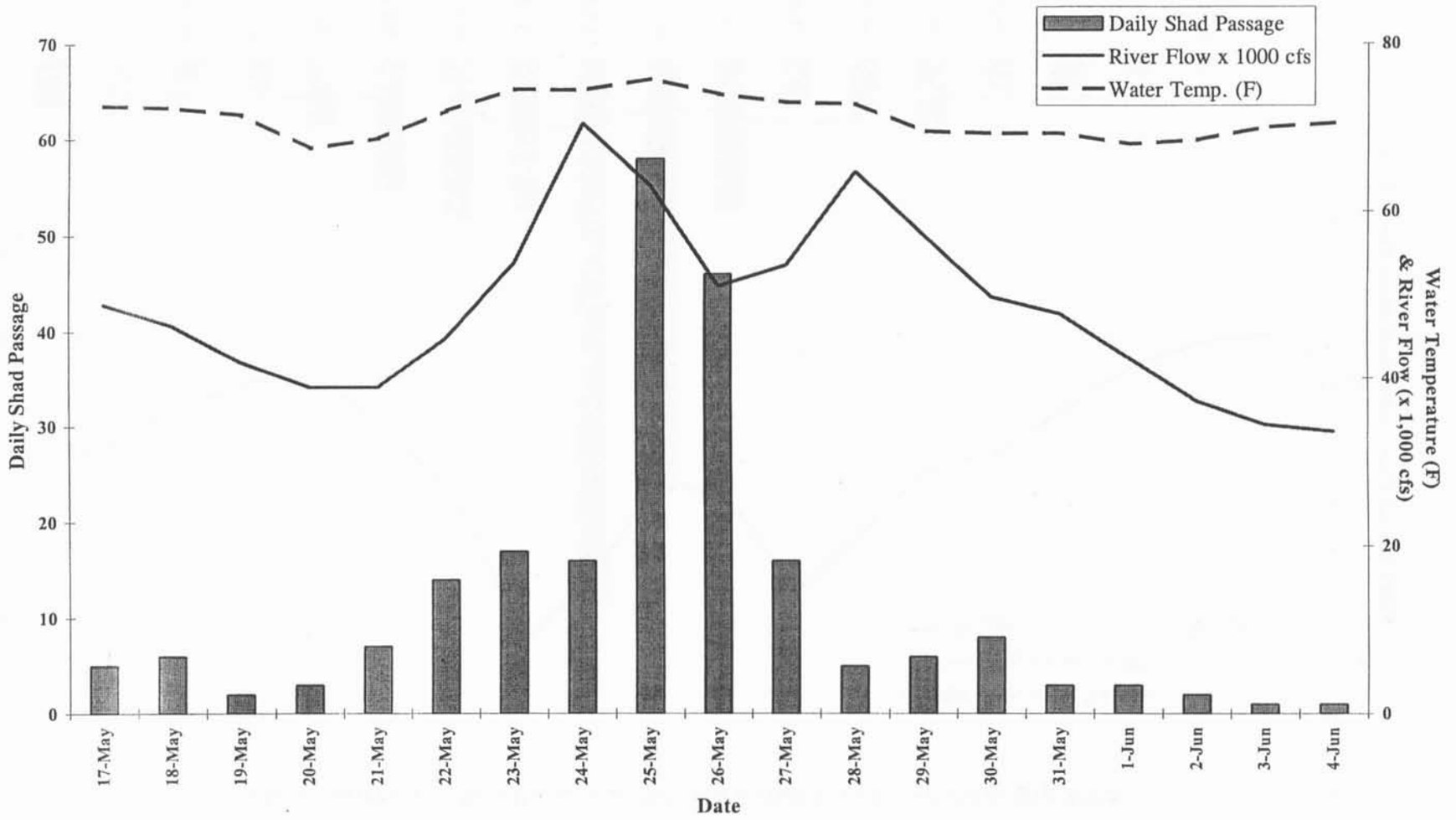


Figure 4. Plot of River Flow (x 1000 cfs) & East Channel Flow (x 1000 cfs) in Relation to the Daily American Shad Passage at the York Haven Fishway in Spring 2004

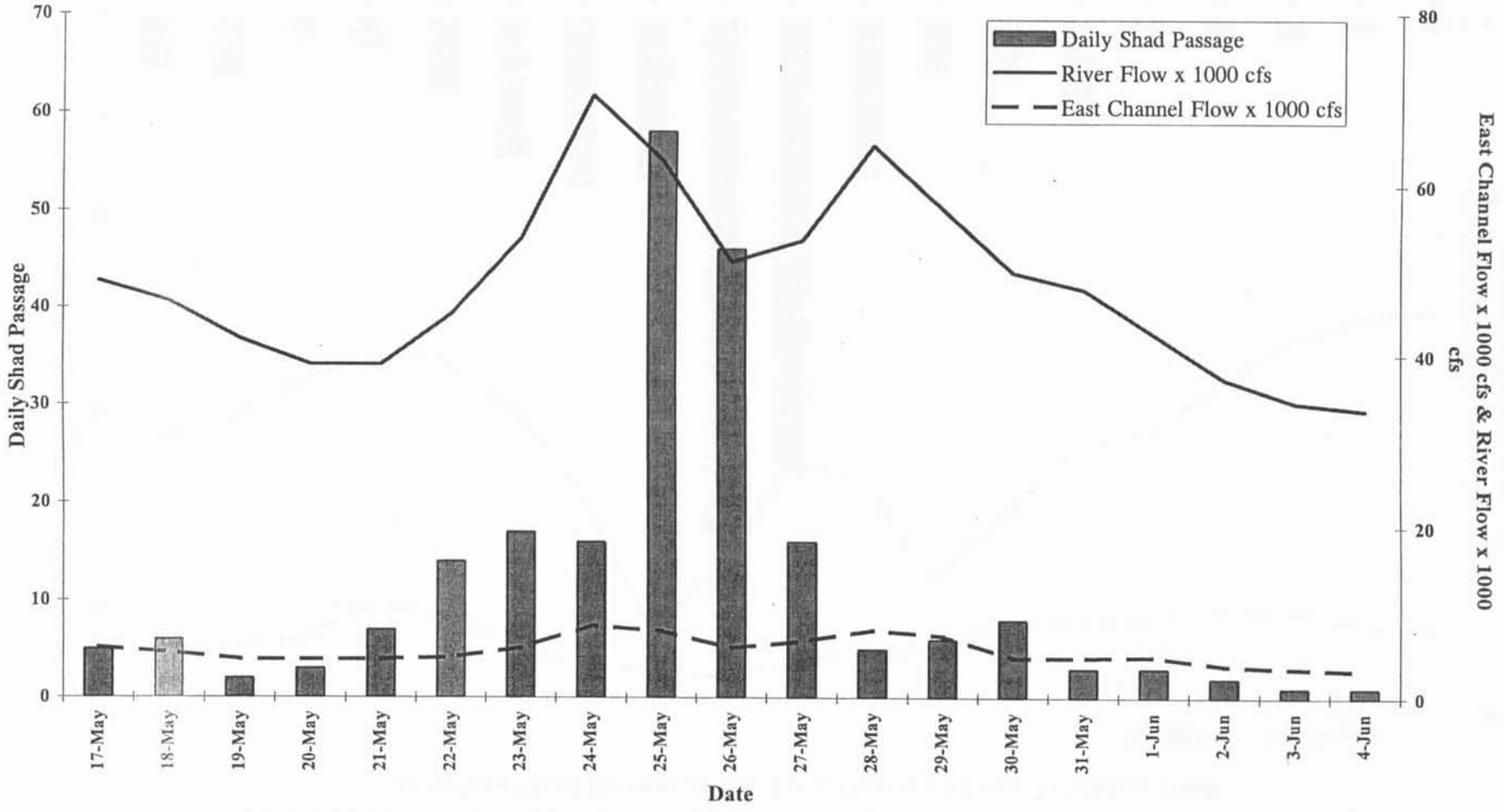


Figure 5. Plot of River Flow (x 1000 cfs) at the USGS Harrisburg Station (#01570500) on the Susquehanna River, September 2004.

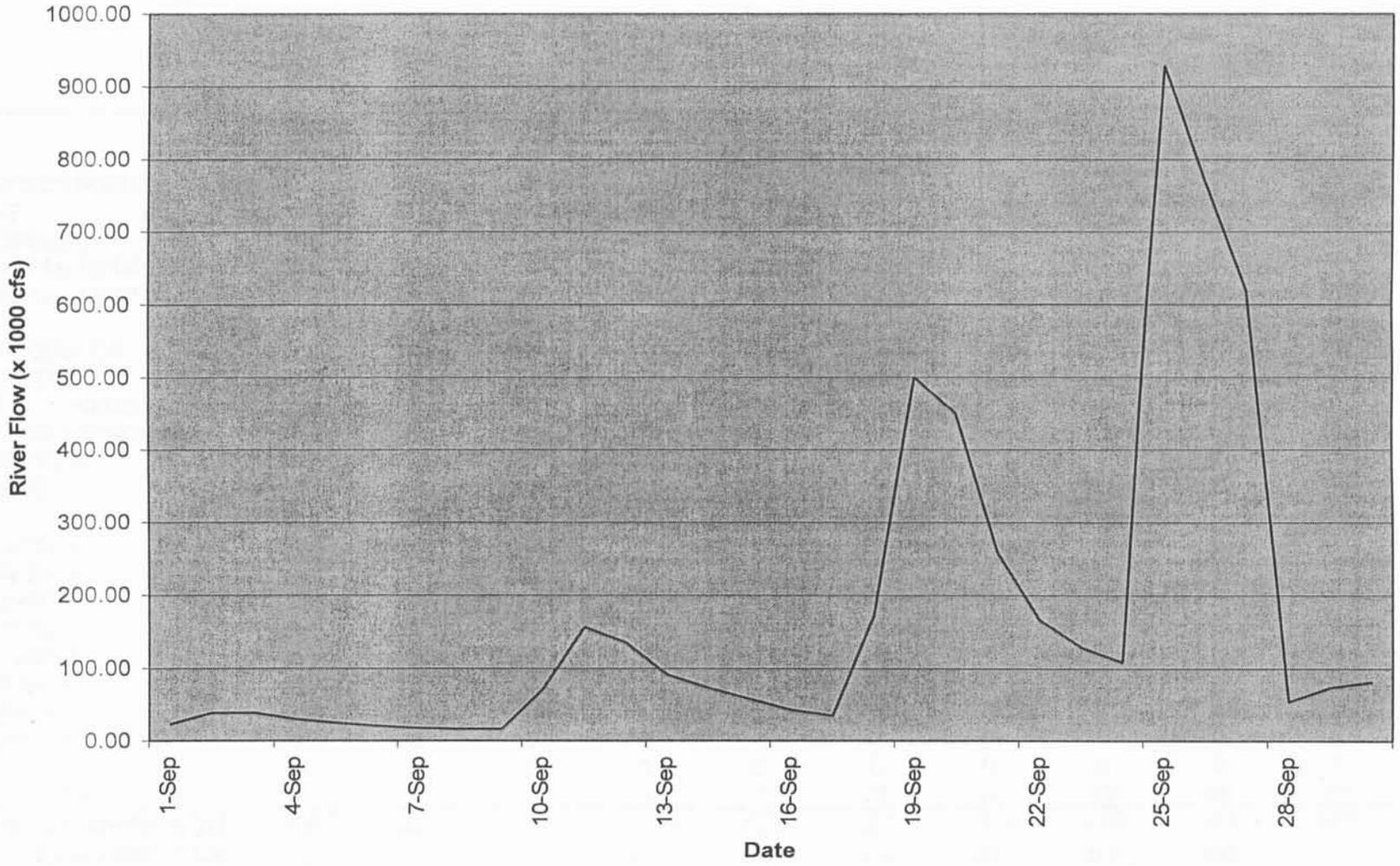


Table 1. Summary of the daily number of fish that passed by the York Haven Hydroelectric Project through the serpentine vertical notch ladder at the East Channel Dam in 2004.

Date	17-May	18-May	19-May	20-May	21-May	22-May	23-May	24-May	25-May	26-May
Observation Time	7.6	7.9	7.0	8.0	8.0	7.5	8.0	9.0	8.0	8.5
Water Temperature (°F)	72.6	72.3	71.5	67.5	68.7	72.0	74.6	74.5	75.8	74.0
AMERICAN SHAD	5	6	2	3	7	14	17	16	58	46
ALEWIFE	0	0	0	0	0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	2,293	12,649	6,591	5,696	6,043	5,497	5,610	9,365	8,663	8,708
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0
STRIPED BASS	0	0	1	1	0	0	0	0	0	0
WHITE PERCH	0	0	0	0	0	0	0	0	0	0
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0
RAINBOW TROUT	0	0	0	0	0	0	0	0	0	1
BROWN TROUT	0	0	0	0	0	0	0	0	0	1
CARP	50	262	70	48	26	24	50	165	33	28
QUILLBACK	1	342	280	172	150	224	261	502	189	232
WHITE SUCKER	0	24	3	21	12	10	4	4	4	2
SHORTHEAD REDHORSE	1	18	27	10	4	6	5	12	2	2
YELLOW BULLHEAD	0	1	0	0	0	0	0	1	0	0
BROWN BULLHEAD	0	0	0	0	0	1	0	2	0	0
CHANNEL CATFISH	1,298	837	255	221	340	623	890	1,523	800	767
BLUEGILL	0	0	0	0	0	0	0	0	0	0
SMALLMOUTH BASS	1	4	4	8	4	22	10	2	17	31
LARGEMOUTH BASS	0	0	1	0	0	0	0	0	0	0
WHITE CRAPPIE	0	1	0	0	0	0	0	0	0	0
WALLEYE	0	51	114	149	77	104	92	60	84	89
FLATHEAD CATFISH	0	0	0	0	0	0	0	2	0	0
Total	**3,649**	**14,195**	**7,348**	**6,329**	**6,663**	**6,525**	**6,939**	**11,654**	**9,850**	**9,907**

Table 1. Continued

Date	27-May	28-May	29-May	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun	Total
Observation Time	8.0	8.0	6.0	8.0	8.0	8.0	8.0	8.0	8.0	150
Water Temperature (°F)	73.0	72.8	69.5	69.3	69.3	68.0	68.5	70.0	70.5	1,354
AMERICAN SHAD	16	5	6	8	3	3	2	1	1	219
ALEWIFE	0	0	0	0	0	0	0	0	0	0
BLUEBACK HERRING	0	0	0	0	0	0	0	0	0	0
GIZZARD SHAD	3,610	2,019	1,949	2,016	903	669	931	504	518	84,234
HICKORY SHAD	0	0	0	0	0	0	0	0	0	0
STRIPED BASS	0	0	0	0	0	0	0	0	0	2
WHITE PERCH	0	0	0	0	0	0	0	0	0	0
AMERICAN EEL	0	0	0	0	0	0	0	0	0	0
RAINBOW TROUT	0	0	0	0	0	0	0	0	0	1
BROWN TROUT	0	0	0	0	0	0	1	0	0	2
CARP	16	16	3	30	5	27	50	42	46	991
QUILLBACK	109	81	12	60	61	109	91	83	107	3,066
WHITE SUCKER	0	2	0	1	2	2	1	2	3	97
SHORTHEAD REDHORSE	6	2	0	0	1	2	4	1	1	104
YELLOW BULLHEAD	0	0	0	0	0	0	0	0	0	2
BROWN BULLHEAD	0	0	0	0	0	0	0	0	0	3
CHANNEL CATFISH	567	792	120	171	86	146	169	155	150	9,910
BLUEGILL	0	0	0	0	1	0	0	0	0	1
SMALLMOUTH BASS	22	2	0	1	1	5	6	11	8	159
LARGEMOUTH BASS	0	0	0	0	0	0	0	0	0	1
WHITE CRAPPIE	0	0	0	0	0	0	0	0	0	1
WALLEYE	87	14	2	8	38	34	87	58	30	1,178
FLATHEAD CATFISH	0	0	0	0	0	0	0	0	0	2
Total	4,433	2,933	2,092	2,295	1,101	997	1,342	857	864	99,973

Table 2. Summary of daily average river flow (USGS, Harrisburg Gage), average flow in the East channel, sum of average flow from power station and main dam, water temperature, secchi, stop log gate position, and East channel and fishway water elevations during operation of the York Haven fishway complex in 2004.

Date	River Flow (cfs)	East Channel Flow (cfs)	Main Dam Flow (cfs)	Water Temp. (°F)	Secchi (in)			Stop log Gate	Elevation (ft)					
									Head Pond			Tailwater		
					Avg.	Min.	Max.		Avg.	Min.	Max.	Avg	Min.	Max.
17-May	48,900	5,900	43,000	72.6	6.0	6.0	6.0	Closed	280.1	280.1	280.1	275.5	275.5	275.5
18-May	46,400	5,300	41,100	72.3	9.0	9.0	9.0	Closed	280.0	280.0	280.1	275.4	275.4	275.4
19-May	42,000	4,500	37,500	71.5	8.0	8.0	8.0	Closed	279.8	279.7	279.8	275.0	275.0	275.0
20-May	39,000	4,500	34,500	67.5	9.0	9.0	9.0	Closed	279.8	279.8	279.8	275.0	275.0	275.0
21-May	39,000	4,500	34,500	68.7	9.0	9.0	9.0	Closed	279.8	279.8	279.8	275.0	275.0	275.0
22-May	44,900	4,750	40,150	72.0	9.0	9.0	9.0	Closed	279.9	279.9	279.9	275.2	275.2	275.2
23-May	53,900	5,900	48,000	74.6	9.0	9.0	9.0	Closed	280.1	280.1	280.2	275.7	275.7	275.7
24-May	70,500	8,500	62,000	74.5	8.0	8.0	8.0	Closed	280.6	280.6	280.6	276.8	276.8	276.8
25-May	63,000	7,900	55,100	75.8	9.0	9.0	9.0	Closed	280.4	280.4	280.5	276.2	276.1	276.3
26-May	51,100	5,900	45,200	74.0	10.0	10.0	10.0	Closed	280.1	280.1	280.1	275.5	275.5	275.6
27-May	53,600	6,700	46,900	73.0	9.0	9.0	9.0	Closed	280.2	280.2	280.3	275.8	275.6	276.0
28-May	64,700	8,000	56,700	72.8	3.0	3.0	3.0	Closed	280.5	280.5	280.5	276.5	276.4	276.5
29-May	57,200	7,300	49,900	69.5	3.0	3.0	3.0	Closed	280.3	280.3	280.3	275.9	275.9	275.9
30-May	49,800	4,750	45,050	69.3	5.0	5.0	5.0	Closed	279.9	279.8	280.0	275.4	275.4	276.0
31-May	47,800	4,750	43,050	69.3	5.0	5.0	5.0	Closed	279.9	279.8	280.0	275.3	275.3	275.3
1-Jun	42,500	4,900	37,600	68.0	7.0	7.0	7.0	Closed	279.9	279.9	279.9	275.0	275.0	275.0
2-Jun	37,200	3,800	33,400	68.5	8.0	8.0	8.0	Closed	279.6	279.6	279.6	274.7	274.7	274.7
3-Jun	34,400	3,500	30,900	70.0	8.0	8.0	8.0	Closed	279.5	279.5	279.5	274.6	274.6	274.6
4-Jun	33,600	3,200	30,400	70.5	6.0	6.0	6.0	Closed	279.3	279.3	279.3	274.6	274.6	274.6

Table 3. Summary of surface water elevations recorded during operation of the York Haven Fishway in 2004.

Date	River Flow (cfs)	Elevation (ft)																				
		Head Pond			Tailwater			Inside Fishway			Inside Weir			Above Counting Room			Below Fixed Wheel Gate			Counting Room		
		Avg.	Min.	Max.	Avg	Min.	Max.	Avg	Min.	Max.	Avg	Min.	Max.	Avg	Min.	Max.	Avg	Min.	Max.	Avg	Min.	Max.
17-May	48,900	280.1	280.1	280.1	275.5	275.5	275.5	276.3	276.3	276.4	279.2	279.1	279.3	279.9	277.9	280.0	277.7	277.6	277.8	279.9	279.9	280.0
18-May	46,400	280.0	280.0	280.1	275.4	275.4	275.4	276.0	276.0	276.0	278.1	278.1	278.1	279.9	279.9	279.9	277.8	277.8	277.8	279.7	279.7	279.8
19-May	42,000	279.8	279.7	279.8	275.0	275.0	275.0	275.6	275.6	275.6	278.0	278.0	278.0	279.6	279.6	279.6	277.7	277.7	277.7	279.6	279.6	279.6
20-May	39,000	279.8	279.8	279.8	275.0	275.0	275.0	275.6	275.6	275.6	278.0	278.0	278.0	279.6	279.6	279.6	277.7	277.7	277.7	279.6	279.6	279.6
21-May	39,000	279.8	279.8	279.8	275.0	275.0	275.0	275.6	275.6	275.6	278.0	278.0	278.0	279.7	279.7	279.7	277.8	277.8	277.8	279.6	279.6	279.6
22-May	44,900	279.9	279.9	279.9	275.2	275.2	275.2	275.8	275.8	275.8	278.0	278.0	278.0	279.8	279.8	279.8	277.8	277.8	277.8	279.7	279.7	279.7
23-May	53,900	280.1	280.1	280.2	275.7	275.7	275.7	276.3	276.3	276.3	278.2	278.2	278.2	280.1	280.1	280.1	278.0	278.0	278.0	280.1	280.1	280.1
24-May	70,500	280.6	280.6	280.6	276.8	276.8	276.8	277.1	277.0	277.2	278.8	278.8	278.8	280.7	280.7	280.7	278.3	278.2	278.3	280.6	280.6	280.7
25-May	63,000	280.4	280.4	280.5	276.2	276.1	276.3	276.8	276.7	276.9	278.5	278.5	278.5	280.4	280.4	280.4	278.0	278.0	278.0	280.3	280.3	280.3
26-May	51,100	280.1	280.1	280.1	275.5	275.5	275.6	276.3	276.3	276.3	278.2	278.2	278.2	280.0	280.0	280.0	277.9	277.9	277.9	280.0	280.0	280.0
27-May	53,600	280.2	280.2	280.3	275.8	275.6	276.0	276.3	276.2	276.4	278.3	278.2	278.4	280.1	280.0	280.2	278.0	278.0	278.0	280.1	280.0	280.2
28-May	64,700	280.5	280.5	280.5	276.5	276.4	276.5	277.1	277.0	277.1	278.6	278.6	278.6	280.5	280.5	280.5	278.2	278.2	278.2	280.5	280.4	280.5
29-May	57,200	280.3	280.3	280.3	275.9	275.9	275.9	276.8	276.8	276.8	280.2	280.2	280.2	280.2	280.2	280.2	278.1	278.1	278.1	280.2	280.2	280.2
30-May	49,800	279.9	279.8	280.0	275.4	275.4	276.0	276.0	276.0	276.1	278.1	278.1	278.1	279.9	279.9	279.9	278.0	278.0	278.0	279.9	279.9	279.9
31-May	47,800	279.9	279.8	280.0	275.3	275.3	275.3	276.0	276.0	276.0	278.1	278.1	278.1	279.8	279.8	279.8	277.8	277.8	277.8	279.8	279.8	279.8
1-Jun	42,500	279.9	279.9	279.9	275.0	275.0	275.0	275.6	275.6	275.6	278.0	278.0	278.0	279.9	279.9	279.9	277.8	277.8	277.8	279.9	279.9	279.9
2-Jun	37,200	279.6	279.6	279.6	274.7	274.7	274.7	275.4	275.4	275.4	277.8	277.8	277.8	279.5	279.4	279.5	277.6	277.6	277.6	279.4	279.4	279.5
3-Jun	34,400	279.5	279.5	279.5	274.6	274.6	274.6	275.2	275.2	275.2	277.8	277.8	277.8	279.4	279.4	279.4	277.6	277.6	277.6	279.3	279.3	279.3
4-Jun	33,600	279.3	279.3	279.3	274.6	274.6	274.6	275.2	275.2	275.2	277.7	277.7	277.7	279.4	279.4	279.4	277.6	277.6	277.6	279.3	279.3	279.3

Table 4. Hourly summary of American shad passage through the sepentine vertical notch fish ladder at the York Haven Hydroelectric Project in 2004.

Date	17-May	18-May	19-May	20-May	21-May	22-May	23-May	24-May	25-May	26-May
Observation Time (Start)	0835	0805	0901	0801	0801	0801	0801	0801	0801	0801
Observation Time (End)	1600	1600	1600	1600	1600	1630	1600	1700	1600	1630
Military Time (Hours)										
0801 - 0900	-	-		-	-	1	4	4	8	5
0901 - 1000	-	-	-	-	1	3	6	1	7	8
1001 - 1100	-	3	-	-	-	1	1	3	8	7
1101 - 1200	-	1	-	1	-	2	3	2	6	8
1201 - 1300	1	1	-	1	1	1	2	3	11	4
1301 - 1400	2	1	-	-	3	5	1	-	14	10
1401 - 1500	2	-	1	1	1	1	-	2	3	3
1501 - 1600	-	-	1	-	1	-	-	1	1	1
1601 - 1700						-		-		-
Total Catch	5	6	2	3	7	14	17	16	58	46

Table 4. Continued

Date	27-May	28-May	29-May	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun		
Observation Time (Start)	0801	0801	0801	0801	0801	0801	0801	0801	0801		
Observation Time (End)	1600	1600	1400	1600	1600	1600	1600	1600	1600	Total	%
Military Time (Hours)											
0801 - 0900	6	1	-	3	-	-	-	-	-	32	14.6%
0901 - 1000	3	1	1	-	-	-	1	-	-	32	14.6%
1001 - 1100	1	1	1	1	1	-	-	-	-	28	12.8%
1101 - 1200	2	-	2	-	1	-	-	1	-	29	13.2%
1201 - 1300	3	1	1	1	-	2	-	-	1	34	15.5%
1301 - 1400	1	-	1	2	-	-	-	-	-	40	18.3%
1401 - 1500	-	1		-	1	1	-	-	-	17	7.8%
1501 - 1600	-	-		1	-	-	1	-	-	7	3.2%
1601 - 1700										0	0.0%
Total Catch	16	5	6	8	3	3	2	1	1	219	100.0%

Job II – Part 1
THE AMERICAN SHAD EGG COLLECTION PROGRAM ON THE HUDSON RIVER, 2004

THE WYATT GROUP, INC.
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INTRODUCTION

The Pennsylvania Fish and Boat Commission (PFBC) is cooperating with other state and federal agencies and hydropower companies to restore the American shad (*Alosa sapidissima*) to the Susquehanna River. The restoration effort is coordinated through the Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC). One component of that effort is production of hatchery-reared American shad larvae at the Commission's Van Dyke Hatchery for stocking in the Susquehanna River. Fertilized American shad eggs are required to initiate the hatchery activities.

The Hudson River has been an important source of viable eggs in support of the hatchery effort. The Wyatt Group, Inc. is contracted to capture ripe adult shad on the spawning grounds during spawning activity, artificially fertilize the eggs, and deliver them to the hatchery. The objective in 2004 was to deliver 10 to 20 million fertilized American shad eggs, with a viability of 60-70 percent.

Since the early 1970's more than 500 million eggs have been obtained as part of the Susquehanna River anadromous fish restoration program. Annual production has ranged from 11 to 52 million eggs per year. The highest production was from the Columbia River, Oregon, which was discontinued in 1989. All subsequent egg collection efforts have been made on the East Coast of the U.S. Since 1989, the primary rivers used have been the Delaware and Hudson rivers (Table 1).

COLLECTING METHODS AND SCHEDULES

Each collecting crew was assigned to a boat equipped with gill nets and the gear required for artificial fertilization and packing of shad eggs. When warranted, they fished simultaneously.

Monofilament gill nets were of 4.0 to 5.5 inch stretch mesh, up to 600 feet long and 8 feet deep. Nets with larger mesh size were used primarily to capture female shad while the smaller mesh nets were used to capture male shad. Each crew set some 900 to 1200 feet of net. Gill nets were mainly anchored at a site and tended regularly after being set, or occasionally drifted and tended after an approximately 30-45 minute drift. Fishing commenced just before dusk and continued until ripe shad were no longer caught. Generally, this was from about 7:00 PM to 1:00 AM. The only collection site used in 2004 was Coxsackie.

The sampling schedule was organized in an order of priority that reflected probability of success based on past experience. It was governed by water temperature, tidal conditions, water turbidity, time of day, and weather. Each variable has an influence on the success of capturing ripe shad. Water temperature was important in deciding the time to commence and end efforts to collect ripe shad. Experience has shown that ripe shad are usually available when waters reach 51°F with larger numbers of eggs being collected at water temperatures of 54-64°F. Some spawning activity may occur up to a temperature of 68°F.

All netting is done in tidal areas. The impact of tidal conditions, although mostly affecting netting efficiency at certain sites, influences the availability of ripe shad. On the Hudson River spawning shad are especially vulnerable to gill netting on the flats and along the shore during the period when the tide changes from ebb to flood. Tide tables were used to decide when gill netting would be most effective at selected sites. At Cheviot and Glasco, the depth at the shoreline prevents the setting of gill nets at ebb tide. At Coxsackie, the water depth is variable (4-10 feet) and gill nets can be set at any tide stage.

PROCESSING AND DELIVERY OF SHAD EGGS

The proper handling of shad and eggs in the field is crucial to egg viability. All processing was done on board the boat and only running ripe females were used. Eggs from 4-6 ripe shad were gently squeezed into a dry collecting pan. Sperm was taken only when eggs were ready to be fertilized. Eggs were fertilized with sperm from up to six males; but preferably, a ratio of one male to three female shad was used in the fertilization process. If the preferred number was not available, eggs and sperm were taken from fewer fish to assure that only live fish were used.

Sperm and eggs were dry mixed for about one minute followed by addition of a small amount of water to activate the sperm and ensure fertilization. After several minutes, eggs were washed repeatedly to remove excess sperm, unfertilized and broken eggs, scales, and blood. Eggs were then placed in large plastic buckets with at least 10 gallons of clean river water and allowed to harden for at least two hours before packaging. Hardened eggs were filtered into doubled plastic bags, five liters of eggs with five liters of clean river water. At least 2 liters of pure oxygen was injected into the bag, which was then secured with castrating rings. When ready for shipment, the bags were placed into coolers and labeled with river location, date of collection, quantity of eggs and water temperature.

When the volume of eggs was five liters or more, eggs were delivered by automobile to the Van Dyke Hatchery. Eggs from each night of collection from both crews were brought to Catskill, NY and loaded for delivery. The goal was to have the eggs arrive at the hatchery between 10:00 and 11:30 AM with all shipments arriving before 3:00 PM the next day. The Field Supervisor (or a designate) notified the hatchery regarding the number of liters of eggs shipped and the estimated arrival time.

RESULTS AND DISCUSSION

The first crew began sampling on May 2. Both crews sampled beginning on May 3. Once the second boat began operations, it was used regularly until egg collection efforts ceased. Egg collection ended on May 26 when water temperature reached 68.5°F. Sampling occurred on 22 dates during this period including 43 boat-days of gill netting. Haul seining was not used during the 2004 shad-fishing season. Weather conditions prevented full-scale egg collection on four nights in 2004; two nights due to lightning and two nights due to fog. Water temperature increased faster than normal in 2004 and had a moderate negative impact on the number of eggs collected in 2004. The impact was greater in efforts after May 11 when water temperatures reached 60.5°F.

A total of 9.4 million eggs were shipped to the Van Dyke Hatchery (Table 2). The goal of 60-70% viability was exceeded with an average of 74.9% and a range from 32.1% to 92.8% in individual shipments.

SUMMARY

A total of 9.4 million American shad eggs were collected from the Hudson River and delivered to the PFBC's Van Dyke Hatchery in 2004. The number of eggs collected was 1.6 million below the average of 11.8 million eggs taken per year since 1989. This is attributed in part to weather conditions preventing full-scale collection and warmer than normal water temperatures over the collection period. Egg viability averaged 74.9%, exceeding the goal of 60-70% established by the PFBC. Higher than average viabilities may be attributed to the use of two independent boat crews which increased the probability of capturing sufficient males to fertilize the eggs obtained by the combined effort.

Table 1. Total number (millions) of American shad eggs collected from the Delaware and Hudson rivers and delivered to the Van Dyke Hatchery, 1983-2004.

Year	Delaware	Hudson	Total
1983	2.40	1.17	3.57
1984	2.64	-	2.64
1985	6.16	-	6.16
1986	5.86	-	5.86
1987	5.01	-	5.01
1988	2.91	-	2.91
1989	5.96	11.18	17.14
1990	13.15	14.53	27.68
1991	10.74	17.66	28.40
1992	9.60	3.00	12.60
1993	9.30	2.97	12.27
1994	10.27	6.29	16.56
1995	10.75	11.85	22.60
1996	8.31	5.69	14.00
1997	11.76	11.08	22.84
1998	10.34	15.72	26.06
1999	5.49	21.00	26.49
2000	3.83	16.40	20.23
2001	6.35	3.90	10.25
2002	2.04	18.51	20.55
2003	3.47	17.27	20.74
2004	2.41	9.39	11.80
Total	148.75	187.61	336.36

Table 2. Collection data for American shad eggs, Hudson River, 2004.

Date	Site	Volume Eggs (liters)	Number of Eggs	PFC Shipment Number	Water Temperature (F)	Percent Viability
2-May	Coxsackie	19.6	652,687	7	58	71.4
3-May	Coxsackie	18.8	561,114	8	57	32.1
4-May	Coxsackie	27.2	886,431	9	56	56.3
5-May	Coxsackie	34.9	1,053,303	10	57	75.3
6-May	Coxsackie	15.0	452,709	12	58	80.7
8-May	Coxsackie	45.8	1,541,616	14	58	78.6
9-May	Coxsackie	29.7	773,023	16	57	72.3
10-May	Coxsackie	3.5	105,632	18	57	79.3
11-May	Coxsackie	15.1	445,675	20	59.5	89.3
13-May	Coxsackie	28.2	919,020	24	62	85.0
15-May	Coxsackie	19.3	514,154	27	65	92.8
16-May	Coxsackie	16.9	556,747	29	65	85.0
17-May	Coxsackie	8.8	293,043	31	66	80.6
18-May	Coxsackie	8.0	280,984	33	68	77.3
19-May	Coxsackie	5.2	184,576	35	67	81.6
22-May	Coxsackie	5.5	169,709	38	68.5	81.7
Total		301.5	9,390,423			

JOB II - Part 2
COLLECTION OF AMERICAN SHAD EGGS FROM THE DELAWARE RIVER, 2004

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Introduction

A key element in the restoration of American shad to areas above dams in the Susquehanna, Lehigh and Schuylkill Rivers is the stocking of hatchery-reared larvae. These larvae imprint to the tributary/river reach in which they are stocked and return to spawn 3 to 6 years later. Hatchery production of larvae is dependant upon reliable sources of good quality eggs. Cost-effective collection of eggs requires intensive sampling efforts in well documented spawning areas where ripe brood fish are abundant.

The Delaware River was first used as a source of American shad eggs in 1973. Between 1973 and 1975, some 1.6 million eggs were collected from the Delaware River and stocked (as eggs) into the Schuylkill River. In 1976, the Lehigh and Schuylkill Rivers each received 80,000 eggs from the Delaware source. The Susquehanna River received its first fry from the Delaware River in 1976 when the surviving larvae from 1.5 million eggs were stocked. Collections of shad eggs from the Delaware River were discontinued from 1977 to 1982. In 1983, egg collection resumed, and has continued annually to the present. The goal of this activity in 2004, as in past years, was to collect and ship up to 15 million American shad eggs.

Methods

Brood fish were captured in gill nets set in the Delaware River at Smithfield Beach (RM 218). In past years, Ecology III of Berwick, PA provided a boat, equipment and labor support to

assist the PFBC Area Fisheries Manager and his staff stationed at Bushkill, PA. In 2000 through 2004, however, the Ecology III contract was not renewed (due to termination of funding) and the PFBC Area Fisheries Manager and his staff completed egg collection without the assistance of Ecology III. In 2004, thirteen or fourteen 200-foot gill nets were set per night with mesh sizes ranging from 4.5 to 6.0 inches (stretch). Nets were anchored on the upstream end and allowed to fish parallel to shore in a concentrated array. Netting began at dusk and, on a typical evening; shad were picked from the nets two or three times before retrieving them at midnight. Both male and female shad were placed into water-filled tubs and returned to shore. Eggs were stripped from ripe female shad and fertilized in dry pans with sperm from ripe males. Once gametes were mixed, a small amount of fresh water was added to activate the sperm and they were allowed to stand for five minutes, followed by several washings. Cleaned fertilized eggs were then placed into floating boxes with fine mesh sides and bottom. Directional fins were added to the mesh areas to further promote a continuous flushing with fresh river water. Eggs were water-hardened for about one hour.

Water- hardened shad eggs were removed from the floating boxes and placed into buckets where excess water was decanted. Eggs were then gently scooped into large, double-lined plastic bags – about 3 liters of eggs and 3 to 5 liters of fresh water. Medical-grade oxygen was bubbled into the bags to super-saturation and they were sealed with rubber castration rings. Bags were then placed into coolers and transported by truck 150 miles to the Pennsylvania Fish and Boat Commission (PFBC) Van Dyke Hatchery near Thompsontown, PA.

After spawning the shad catch data was recorded for all shad including gillnet mesh size, sex, length (total and fork) and weight. Representative samples of each night's catch of both sexes were collected for scale and otolith analysis. Ovaries from mature/gravid females were also removed and weighed. Most adult shad did not survive the rigors of netting and artificial spawning and it was

necessary to properly dispose of the carcasses. The National Park Service provided a disposal pit on park property and shad carcasses were delivered there each night and covered with hydrated lime.

Results and Discussion

Table 1 summarizes daily Delaware River shad egg collections during May 2004. American shad spawning operations commenced on May 9, when river flow was 7,870 cfs (USGS gauge at Montague, NJ) and river temperature was 15° C (59° F). Egg take ended on May 27, when river flow was 4,660 cfs and temperature was 21° C (69.8° F). Most of the 2004 egg-take operation was conducted during a window of decreasing flow and rapidly increasing temperature conditions (Figure 1, Table 1). All of the successful egg collections occurred when flow was near or below 62-year median flows (Figure 1). Egg collections were negatively impacted by rapidly increasing water temperatures which contracted the spawning period and reduced egg viability.

Nets were set on 15 nights with 13-14 nets set on each night. The usual number of nets set per mesh size (stretch, inch) each night was: 4.50- 2-3 each; 4.75- 1 each; 5.00- 4-5 each; 5.25- 1 each; 5.50- 1 each; 5.75- 1 each; and 6.00- 2 each.

A total of 427 adult American shad were caught (Table 1). Nightly catches ranged from 3 to 62 shad. Sex ratio (male to female) was 0.58:1. A total of 60.3 L (2.4 million) of fertilized eggs were collected and shipped to the Van Dyke Hatchery. Some 0.5 L of fertilized eggs were collected on May 12, but were released back into the river. From 1983 to 2004, 150 million American shad eggs were collected from the Delaware River. From those eggs, some 29 million larvae have been stocked in the Susquehanna River, 14.6 million in the Lehigh River and 4.3 million in the Schuylkill River. In 2004, some 366 thousand American shad larvae were stocked in the Lehigh River and 422 thousand were stocked in the Schuylkill River.

Summary

Shad eggs were collected and shipped on 13 of the 15 nights that were fished from 9 May through 27 May 2004. During this time, 427 adult shad were captured and 60 liters of eggs were shipped for a hatchery count of 2.4 million eggs. Overall, the viability for Delaware River American shad eggs was 43%.

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Figure 1. American shad egg collections and flow, Delaware River, 2004.

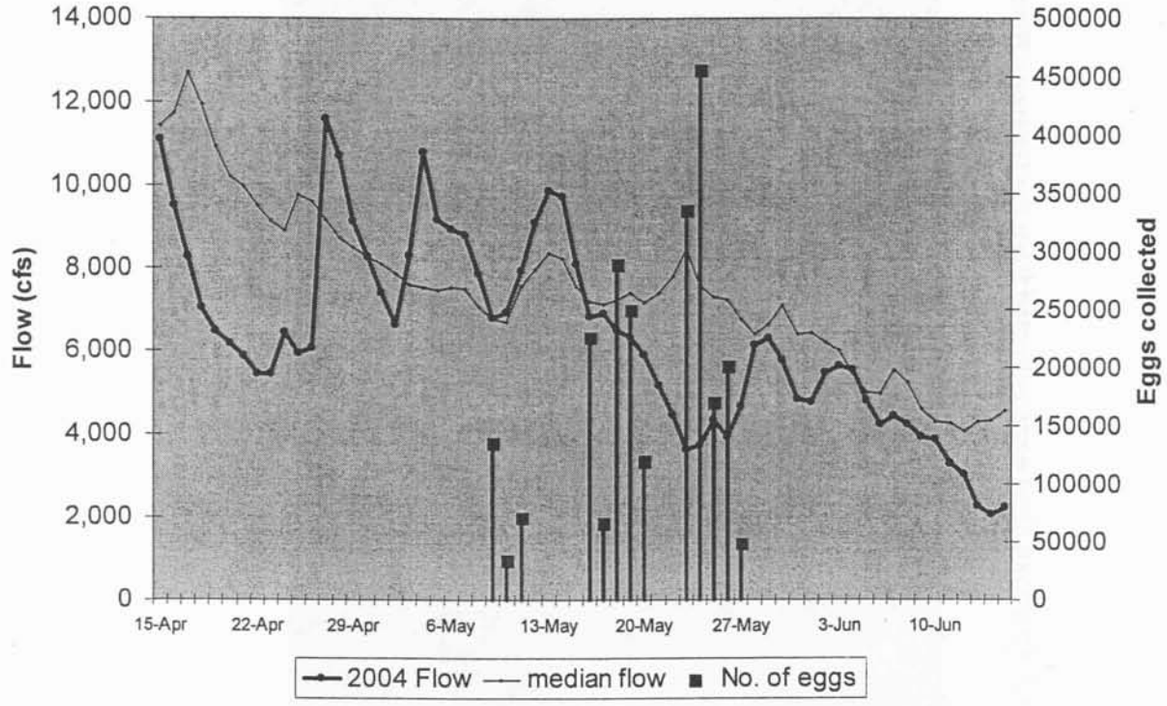

Figure 2. American shad eggs collected from the Delaware River, 1983-2004.

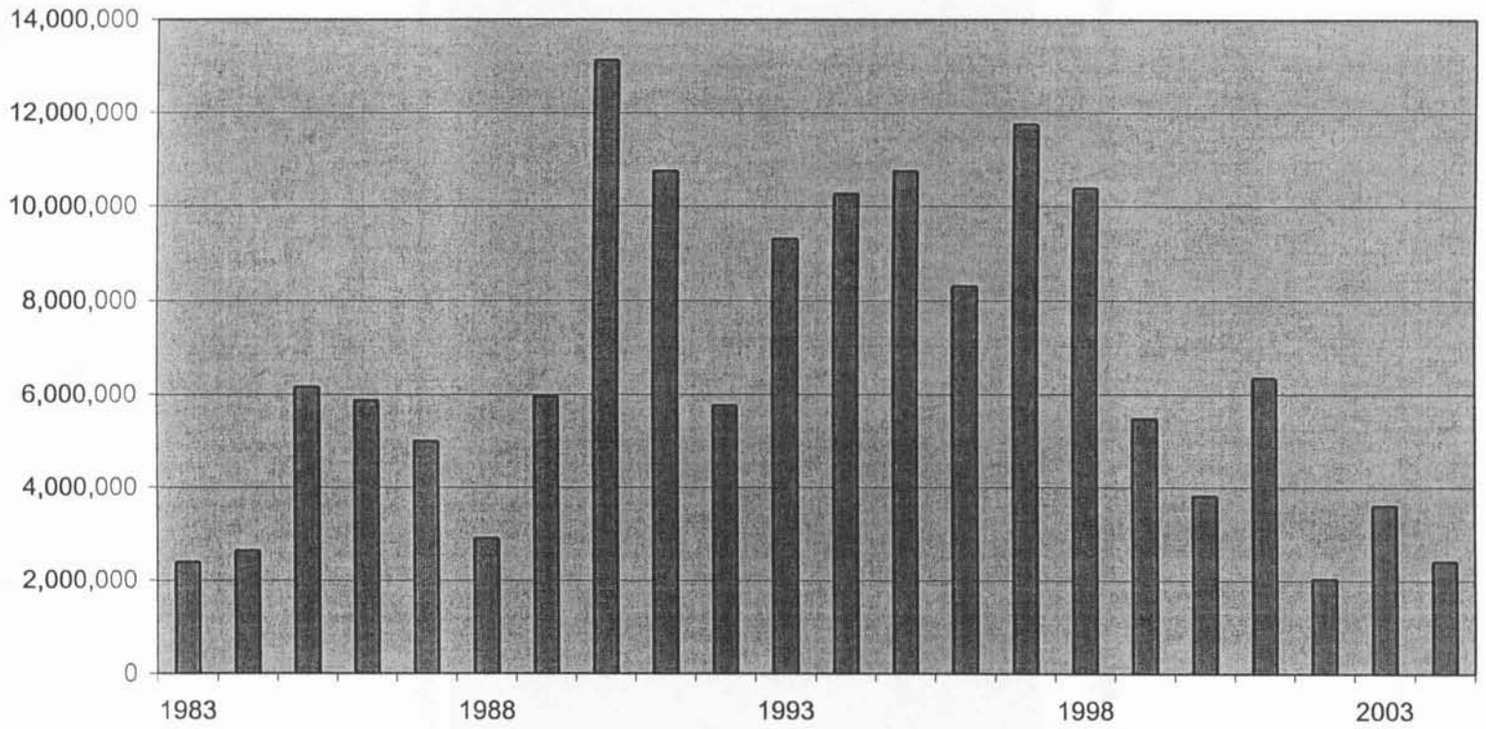

Table 1. Delaware River American shad egg collection, 2004.

Month	Day	Year	Location	Water Temp C	No. of Nets	No. of Shad Captured	Volume (L)	Eggs	Viable Eggs	Percent Viable
5	9	2004	Smithfield Beach	15	14	23	4.3	135,630	52,283	38.5%
5	10	2004	Smithfield Beach	16	14	12	1.2	34,242	18,738	54.7%
5	11	2004	Smithfield Beach	18	13	19	2.4	71,632	33,206	46.4%
5	12	2004	Smithfield Beach	18	13	5	no shipment			
5	13	2004	Smithfield Beach	19	13	3	no shipment			
5	16	2004	Smithfield Beach	20	14	26	8.7	226,441	141,849	62.6%
5	17	2004	Smithfield Beach	20	14	19	2.1	66,966	24,144	36.1%
5	18	2004	Smithfield Beach	20	14	43	8.6	289,474	231,390	79.9%
5	19	2004	Smithfield Beach	19	14	31	7.2	250,224	175,550	70.2%
5	20	2004	Smithfield Beach	19	14	38	3.9	120,339	66,283	55.1%
5	23	2004	Smithfield Beach	22	14	62	6.2	335,467	56,608	16.9%
5	24	2004	Smithfield Beach	22.5	14	56	7.0	456,258	85,352	18.7%
5	25	2004	Smithfield Beach	23	14	34	2.8	170,238	18,207	10.7%
5	26	2004	Smithfield Beach	21	14	32	4.4	200,990	96,164	47.8%
5	27	2004	Smithfield Beach	21	14	24	1.5	48,884	35,224	72.1%
					Total	427	60.3	2,406,785	1,034,998	43.0%

JOB II – PART 3
REPORT ON HORMONE-INDUCED SPAWNING TRIALS WITH AMERICAN AND HICKORY SHAD AT CONOWINGO DAM, SPRING 2004

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BACKGROUND

For over a decade, the Pennsylvania Fish and Boat Commission Van Dyke Hatchery has utilized strip spawned American shad eggs from Hudson and Delaware River broodstock to produce and stock over 130 million shad larvae in the Susquehanna River. The importance of these hatchery releases is evidenced by the high percentage (75-90%) of hatchery origin shad in the Susquehanna River spawning runs in the early to mid 1990's. Since the mid 1990's Susquehanna River shad stocks have continued their growth and the contribution of hatchery fish has ranged from 30 to 75%.

The planned annual removal of up to 15 million shad eggs from the Delaware River and up to 20 million eggs from the Hudson River has become controversial or questioned by state agencies. In an effort to reduce the costs and controversy of out of basin egg shipments, three options were proposed for the Annual Work Plan in 2001. Option 1 was the strip spawning of adult broodfish collected from known spawning areas in the Lower Susquehanna River. Option 2 was the hormone-induced spawning of shad broodfish on site at the Conowingo Dam West Fish Lift and Option 3 was the combination of Options 1 and 2. Option 2 was selected for the Annual Work Plan in 2001 and, with modifications, this plan was continued in 2002. Option 3 was selected for the Annual Work Plan in 2003 and 2004 with the addition of hormone induced spawning of hickory shad included in the Plan.

INTRODUCTION

The Conowingo Dam West Fish Lift was built in 1972 and has been operated annually during the months of April, May and early June. Initially it was an integral part of the anadromous fish restoration effort, which combined the operation of the West Fish Lift, hand sorting of target species and a fleet of transport trucks to carry American shad and other alosines to upriver release sites. Since the completion of permanent fish lifts at Conowingo Dam (1991), Holtwood and Safe Harbor Dam (1997), and a fish ladder at York Haven Dam (2000), the Conowingo West Fish Lift is now operated under contract as (1) a source of shad brood fish for on-site induced spawning and for similar culture operations at Maryland Department of Natural Resources Manning Hatchery, and (2) collection of biological information from American shad. In past years, the West Fish lift has also provided pre-spawn American shad for spawning

studies at the USFWS Northeast Fishery Center at Lamar, PA and adult herring for the Pennsylvania Fish and Boat Commission's tributary stocking program.

In typical years, the West Fish Lift operates daily from 11 AM to 7 PM from late April through early June and captures about 10,000 adult American shad. The majority of these fish are in a pre-spawn condition and, based on results at Lamar and Manning, many of these fish could be induced to spawn in two to three days with hormone implants. The advantage of conducting spawning studies on site at Conowingo Dam rather than at a distant hatchery is the elimination of the stress associated with lengthy transport times. The West Fish lift captures few, if any, hickory shad in a typical year. Anglers however are quite successful catching hickories at Shures Landing in Conowingo Fisherman's Park and at the mouth of Deer Creek. Cooperating anglers at these sites provided the source of pre-spawn hickory shad for the 2004 trials.

METHODS AND MATERIALS

Hickory shad spawning trials began on 19 April to coincide with the mid-April start up for the Van Dyke Hatchery and were terminated on 26 April when the angler catch of hickory shad began to decline. Normandeau personnel cooperated with Maryland DNR and PFBC biologists to obtain pre-spawned hickory shad broodstock for the Conowingo trials and DNR's trials at Manning Hatchery. Hickory shad caught at the mouth of Deer Creek were transported to the Conowingo West Lift holding tanks by DNR and PFBC tank trucks.

Broodstock for the first five American shad spawning trials, conducted between 27 April and 11 May, was collected from shore anglers just downstream from the Conowingo West Fish lift or from anglers at the Shures Landing Boat Launch. Fish were shuttled to the holding tanks at the West Lift in a small transport tank in the bed of a pick-up truck. Repairs to the entrance weirs of the West Lift on 13 May permitted operation of the West Lift and the broodstock for the remaining five trials was collected from the Lift. The 2004 American shad trials were patterned after similar trials conducted by USFWS at Lamar in previous years and on the trials conducted at Conowingo Dam from 2001 to 2003.

The 10 ft and 12 ft diameter fiberglass tanks used for spawning trials in 2004 were the same tanks that were used in 2002 and 2003. These tanks were assembled on-site at the West Fish Lift in early April and plumbed in a configuration similar to that used last year (Figure 1). Both tanks were supplied with 25-40 gpm of river water through a wall mounted 2-inch fitting. A screened 4-inch PVC drainpipe in the bottom of each tank provided the only exit for the demersal shad eggs and water from the tank. The water level in both spawning tanks was maintained by an external standpipe that also provided a source of water for the

rectangular 72 by 36 by 16 inch raised egg collection tank. The calculated volumes for the small and large tanks were 6,400 and 9,200 liters respectively. An egg sock fastened to the discharge from the standpipe prevented the shad eggs from entering the internal standpipe drain that maintained the water level in the egg tank.

The stocking rate for adult hickory shad was 60 and 100 fish for the small and large tanks respectively with a 3:2 (M/F) sex ratio, if available. Each of the four hickory shad trials was a single tank trial. The stocking rate for the larger American shad was 50 and 75 fish for the small and large tanks, respectively, with the same 3:2 sex ratio as hickory shad. Seven of the 10 American shad trials used both 10 and 12 ft tanks and the remaining three were single tank trials. All on-site spawning trials in 2004 were conducted with Lutenizing Hormone Releasing Hormone (LHRH) which was purchased in powder form (25 mg vials) from Syndel Labs, Vancouver BC. A portion of the powdered LHRH was converted to 50 and 150 ug cholesterol based pellets by the PFBC. The remaining powder was used to make an injectable saline solution that contained 50 ug/ml for hickory shad trials, or 150 ug/ml for American shad trials. The injectable solution was prepared just before use due to its short shelf life. Both sexes within each species received equal dosages of LHRH. Each fish was injected with a pelletized implant or liquid in the thick muscles of the shoulder area. Fish were not anesthetized prior to injection.

The egg sock was examined daily during each spawning trial. If eggs were present, they were transferred into a framed nylon net, sieved to remove scales and measured for volume with a graduated 2 liter measuring cup. The packaging of eggs for shipment followed well-established techniques. Up to five liters of water hardened eggs were mixed with 5 liters of ambient river water in double plastic bags. Pure oxygen was introduced into the inner bag before being sealed with tape or rubber band. The bags were placed into marked insulated shipping containers and driven to the PFBC Van Dyke facility by PFBC or Normandeau personnel. All shipments of eggs were driven to Van Dyke on the same day they were collected. When less than 5.0 liters of American shad eggs were collected in a day they were released below the dam. Upon trial completion, (usually within 48 hours following injection with LHRH) the tanks were drained, mortalities recorded, and the fish buried at an off-site location. No attempts were made to hand strip shad following the egg pulse.

RESULTS

Hormone induced spawning trials with hickory shad at Conowingo Dam began on April 19 and concluded on April 26, 2004. During this interval, 4 spawning trials (3 pellet and 1 liquid LHRH) were conducted with 349 adult hickory shad (Appendix Table A-1). Two of the trials were conducted in the 10 ft tank and

two in the 12 ft tank. Each trial ran from two to four days but the largest pulse of eggs was produced on the second day. A total of 33.4 liters of eggs was collected from the hickory shad trials and shipped to the Van Dyke Hatchery (Table 1). The overall viability of the hickory shad eggs sent to the Van Dyke Hatchery was 46.1% (Mike Hendricks, personal communication). Water temperature in the spawning tanks ranged from 13 to 18°C and dissolved oxygen levels ranged from 8.6 to 10.1 ppm. Adult mortality rate for hickory shad during the spawning trials was 3.7%.

A total of 10 on-site spawning trials with 1055 American shad followed the hickory shad trials and produced 90.4 liters of eggs (Table 2 and Appendix Table A-2). A total of 79.3 liters was shipped to the Van Dyke Hatchery and 11.1 liters were released into the river below Conowingo Dam. All trials produced a measurable volume of eggs except trial seven when loss of power to the water supply pumps resulted in the loss of all fish. The first American shad trial began on April 27 and the last trial finished on May 27. Nine of the trials were conducted with pelletized hormone implants and one with liquid injections. The 3:2 sex ratio in favor of males was achieved in most trials as well as the stocking density of 1 fish per 125 liters of water. Both sexes received an identical dose of 150 ug LHRH. The total volume of eggs produced per female in individual 2004 trials (0.0-0.36 liters) was the lowest observed to date, (Figure 2). When adjusted for viability, the volume of viable eggs produced per female in the 2004 trials was lower than 0.1 liter in all trials (Figure 3). Water temperatures and oxygen levels in the spawning tanks were monitored daily and ranged from 15 to 26.1°C and 5.6 to 9.2 ppm, respectively. Warmer than normal weather conditions in May elevated river temperatures to above 21°C by May 14. Water temperature in the spawning tanks reached a high of 26.1°C on May 25. These elevated water temperatures combined with the use of partially spent females are the probable cause of the poor egg production experienced in the last three spawning trials with American shad. The overall estimated viability of the eggs shipped to Van Dyke was 20.0% (Mike Hendricks, personal communication). Mortality rate for adult American shad averaged 11.5% during the 2004 trials. This rate excludes the 125 fish lost in trial seven due to a power failure. Mortality ranged from 2 to 6% in previous years.

SUMMARY

The results of the hickory shad spawning trials at Conowingo Dam in 2003 and 2004 showed that a 50 ug dose per fish of liquid or pelletized LHRH effectively induced spawning in hickory shad at stocking densities of up to one fish per 92 liters of water. The estimated overall egg viability of 46.1% observed in 2004 is higher than the 10 to 33% viability estimates for on-site spawning trials with American shad since 2001. Hickory shad trial #3 using liquid LHRH produced only 1.3 liters of eggs, but 95% of those eggs were viable.

This was the fourth year of hormone induced American shad spawning trials at the Conowingo West Fish Lift. In 2004, 9 of the 10 trials utilized pelletized LHRH. The production of 90.4 total liters of American shad eggs at Conowingo in 2004 is the lowest amount of eggs produced since the start of spawning trials in 2001. The sudden rise in water temperature experienced in May 2004 may have hampered egg production. Trials 8 through 10 each produced less than 5 liters of eggs with extremely low viabilities.

Table 1

Summary of egg production data for hormone-induced spawning trials conducted with Hickory shad at Conowingo Dam, spring 2004.

Trial Number	Liquid/ Pellet	Tank	Start/Stop Date	M/F	Egg Vol. (Liters)	Number of Eggs	Proportion Viable	Number Viable
1	P	12 ft	4-19/4-22	52/50	18.9	7,010,347	0.288	2,018,110
2	P	10 ft	4-20/4-23	41/31	11.9	5,485,613	0.633	3,475,002
3	L	12 ft	4-23/4-26	60/43	1.3	516,419	0.95	490,512
4	P	10 ft	4-23/4-26	41/31	1.3	543,126	0.482	261,635
Totals				**194/155**	**33.4**	**13,555,505**	**0.461**	**6,245,259**

Total Males =194
Total Females =155
Total Fish =349

Mean liters/trial = 8.4 liters
Mean No. of Eggs/ Liter = 405,853
Mean Egg Viability = 46.1%

Mean No. of Eggs/Female = 87,455
Mean No, of Viable Eggs/ Female = 40,292

Table 2

Summary of American shad egg production data for hormone-induced spawning trials conducted in a 10 and 12 ft diameter tank at Conowingo Dam, spring 2004.

Trial Number	Liquid/ Pellet	Start/Stop Date	M/F		Liters				River Releases	No. eggs Shipped	Proportion Viable	Number Viable
			12 ft	10 ft	12 ft	10 ft	Total	Shipped				
1	P	4/27-4/29	45/30	30/20	9.5	8.3	17.8	17.8		1,130,537	0.270	305,483
2	P	4/29-5/3	45/30		10.2		10.2	6.6	3.6	383,883	0.289	110,945
3	P	5/4-5/6	45/30	30/20	6.5	6.9	13.4	13.4		751,892	0.116	87,050
4	P	5/6-5/10	45/30	30/20	7.6	10.4	18.0	16.8	1.2	812,844	0.202	163,829
5	P	5/11-5/13		28/20		5.8	5.8	5.8		436,021	0.282	123,016
6	P	5/13-5/16	45/30	30/20	10.0	4.4	14.4	14.4		875,512	0.131	115,097
7	P	5/16-5/17	45/30	30/20	*	*	*	*				
8	P	5/18-5/20	45/30	30/20	3.5	1.0	4.5	4.5		349,506	0.128	44,656
9	P	5/20-5/23	45/30	34/20	3.0	0.9	3.9		3.9			
10	L	5/25-5/27		33/20		2.4	2.4		2.4			
Totals			**360/240**	**275/180**	**50.3**	**40.1**	**90.4**	**79.3**	**11.1**	**4,740,195**	**0.20**	**950,074**

Total Males = 635
Total Females = 420
Total Fish = 1055
Mean vol. / trial (9 trials) = 10.0 liters

Mean Egg Viability (7 Trials) = 20%
Mean No. of Eggs/Female (7 Trials) = 15,801
Mean No, of Viable Eggs/ Female (7 Trials) = 3,167
Mean No. of Eggs / Liter (7 Trials) = 59,775

*Trial not completed due to loss of water supply and all fish.

Table 3

Summary of hormone induced spawning trials with American shad at Conowingo Dam, 2001-04.

Year:	**2001**	**2002**	**2003**	**2004**
Start/Finish date	4-30/6-4	4-24/6-6	4-28/6-5	4-27/5-27
Tank diameter	12 ft	10,12 ft	10,12 ft	10,12 ft
Tank volume	9,200 liters	15,600 liters	15,600 liters	15,600 liters
Number of trials	10	10	12	10
Total fish	599	1000	1504	1055
Males/Females per trial	36/24	66/34	75/50	75/50
Stocking density (fish/liters)	1/153	1/156	1/125	1/125
Male:Female ratio	1.5:1	2:1	3:2	3:2
Hormone injected	LHRH	SGnRHa	LHRH	LHRH
Liquid, Pellet	P	P	L+P	L+P
Dose (ug) Male/Female	75/150	150/150	150/150	150/150
Eggs collected (liters)	103	146.8	234	90.4
Liters of eggs /Female	0.429	0.432	0.387	0.244
No. eggs/liter	63,140	51,235	51,187	59,775
Total number of eggs	6,503,420	7,521,346	11,970,764	5,403,660
Viability (%)	33.2	10.1	17.7	20
Total number of viable eggs	2,159,135	760,935	2,118,852	1,080,732
Total liters of viable eggs	34.20	14.85	41.42	18.1
Adult mortality rate (%)	6.0	3.6	2.0	11.5*

* Does not include total loss of fish in trial 7 due to power loss.

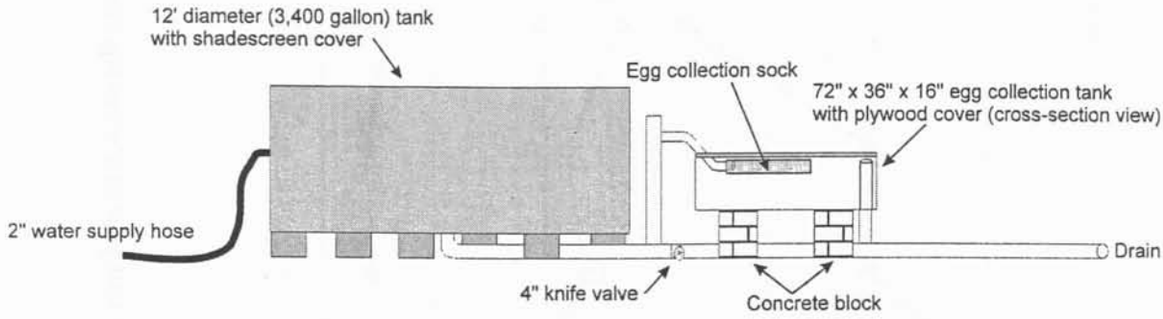

Figure 1. Schematic of tank spawning system used at Conowingo Dam West Fish Lift.

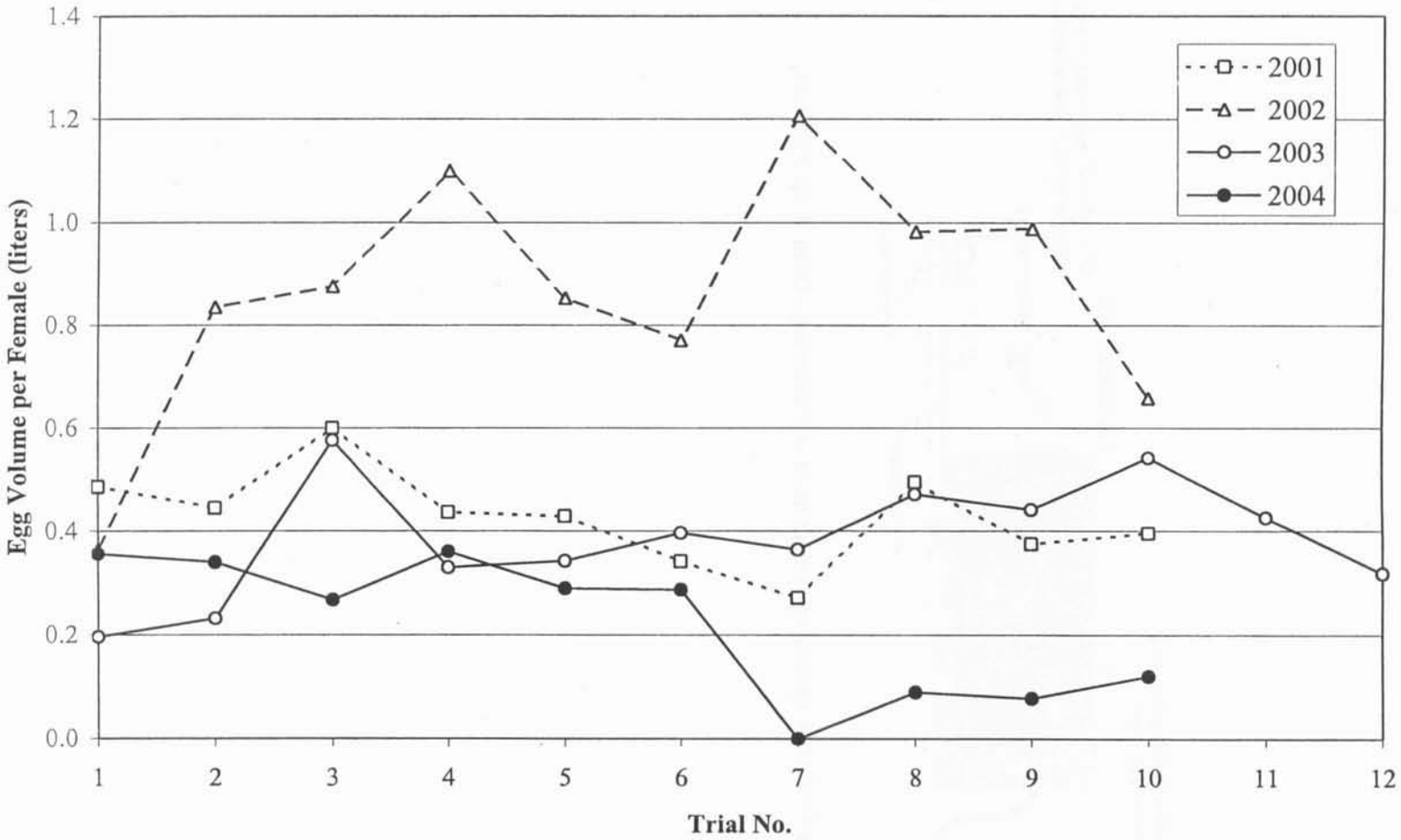

Figure 2 Comparison of American shad egg production per female by trial number and year at Conowingo Dam, 2001-2004.

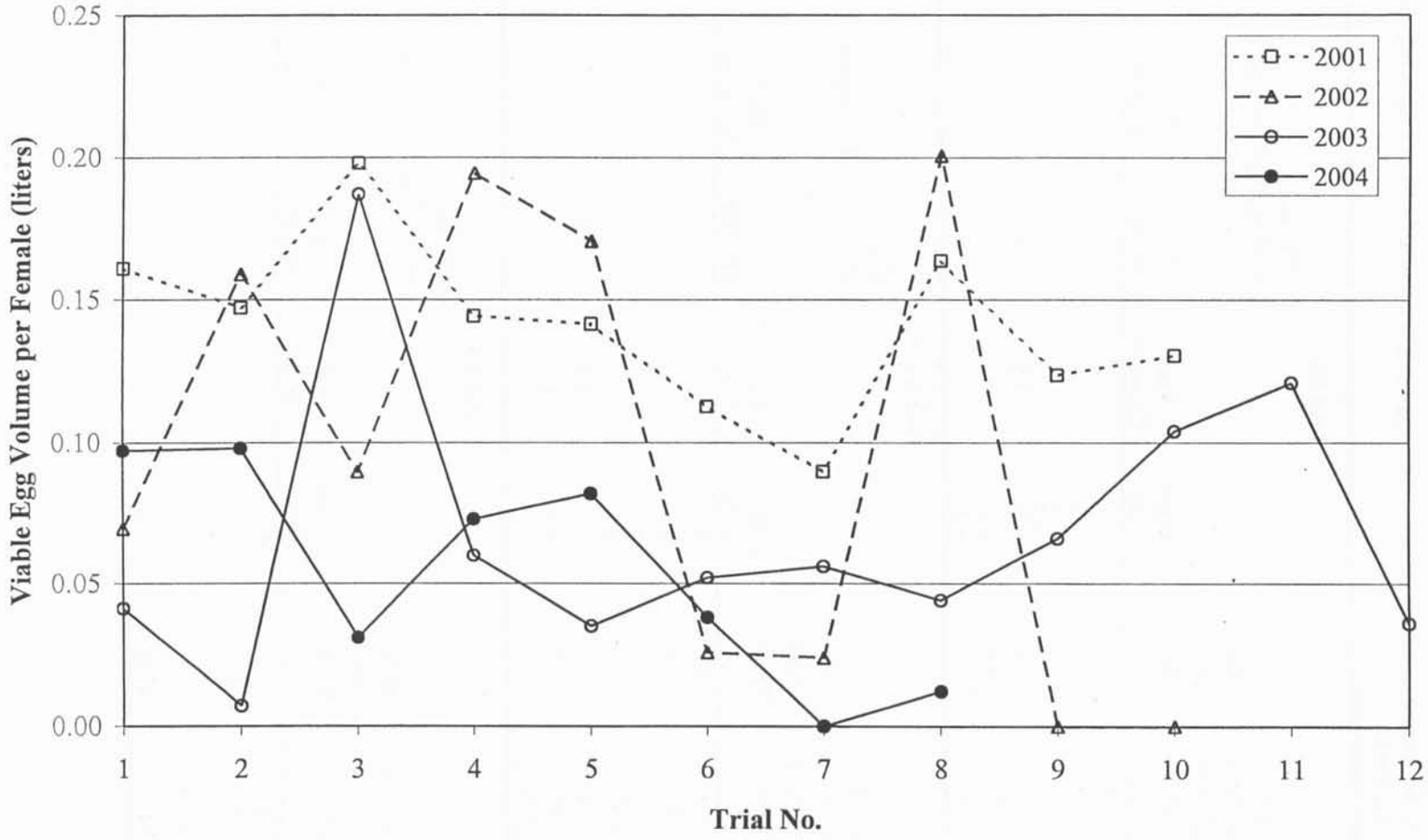

Figure 3 Comparison of viable American shad eggs produced per female by trial number and year at Conowingo Dam, 2001-2004.

Appendix Table A-1

Individual trial data for hormone induced hickory shad spawning trials conducted at Conowingo Dam West Fish Lift, spring 2004.

Trial No. 1

					12 ft tank		
M/F Ratio	52/50				Dose/fish 50ug LHRH pellet		
Start Date	4/19/2004	1600					
End Date	4/22/2004	1500					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
4/19/2004	1630	13	9				
4/20/2004	1430	15	9.6				
4/21/2004	0750	14.6	10.1				
4/21/2004	1330	15.5	9.6	18.9	18.9		
4/22/2004	0730	15.8	9.4				
4/22/2004	1300	17.3	8.8	1	1		0

Trial No. 2

					10 ft tank		
M/F Ratio	41/31				Dose/fish 50ug LHRH pellet		
Start Date	4/20/2004	1415					
End Date	4/23/2004	1000					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
4/20/2004	1430	15.2	9.8				
4/21/2004	750	14.5	10				
4/21/2004	1420	15.3	9.6				
4/22/2004	730	15.8	9.4				
4/22/2004	1300	17.3	9	10.9	10.9		
4/23/2004	740	16.4	9.4	0			
4/23/2004	1000						9f, 4m

Trial No. 3

					12 ft tank		
M/F Ratio	60/43				Dose/fish 50ug LHRH liquid		
Start Date	4/23/2004	1130					
End Date	4/26/2004	900					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
4/23/2004	1300	18	8.9				
4/24/2004	1100	18	9				
4/25/2004	1010	17.7	8.9				
4/25/2004	1030			1.3	1.3		
4/26/2004	820	17.8	9.4				0

Appendix Table A-1

Continued.

Trial No. 4

M/F Ratio	41/31	10 ft tank			Dose/fish 50ug LHRH pellet		
Start Date	4/23/2004	1230					
End Date	4/26/2004	900					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
4/23/2004	1300	18	8.6				
4/24/2004	1100	18	9.1				
4/25/2004	1010	17.6	8.7				
4/25/2004	1030			1.3	1.3		
4/26/2004	820	17.6	9.1				0

Appendix Table A-2

Individual trial data for hormone induced American shad spawning trials conducted at Conowingo Dam West Fish Lift, spring 2004.

Trial No. 1

M/F	30/20	10 ft tank			LHRH 150ug pellets		
Start Date	4/27/2004	0830					
End Date	4/29/2004	1100					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
4/27/2004	1100	17.5	8				
4/27/2004	1355	17.3	7.6				
4/28/2004	0737	15.7	902				
4/29/2004	0740	15	9.2				
4/29/2004	1000			8.3	8.3		1f
M/F	45/30	12 ft tank			LHRH 150ug pellets		
Start Date	4/27/2004	1100					
End Date	4/29/2004	1100					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
4/27/2004	1100	17.5	7.4				
4/27/2004	1355	17.3	7.8				
4/28/2004	0738	15.7	8.8				
4/29/2004	0740	15	9.1				
4/29/2004	1000			9.5	9.5		1f

Trial No. 2

M/F	**45/30**	12 ft tank			LHRH 150ug pellets		
Start Date	4/29/2004	1300					
End Date	5/3/2004	800					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
4/29/2004	1320	15.5	8.7				
4/30/2004	1140	15.8	8.9				
5/1/2004	0950	16.5	9.0				
5/1/2004	1100	16.8	9.0	6.6	6.6		
5/3/2004	0740	18	8.4	3.6		3.6	5m,5f

Trial No. 3

M/F	30/20	10 ft tank			LHRH 150ug pellets		
Start Date	5/4/2004	0800					
End Date	5/6/2004	1030					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/4/2004	1441	18	8.8				
5/5/2004	1415	17.9	8.1				
5/6/2004	0735	17.2	8.6				
5/6/2004	1000			6.9	6.9		1m

Appendix Table A-2

Continued.

Trial No. 3, Continued.

M/F	45/30	12 ft tank			LHRH 150ug pellets		
Start Date	5/4/2004	900					
End Date	5/6/2004	1030					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/4/2004	1441	18	8.9				
5/5/2004	1415	17.9	7.5				
5/6/2004	0735	17.2	8.3				
5/6/2004	1000			6.5	6.5		2f

Trial No. 4

M/F	30/20	10 ft tank			LHRH 150ug pellets		
Start Date	5/6/2004	1200					
End Date	5/10/2004	1100					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/6/2004	1240	18.4	7.4				
5/7/2004	1220	18.3	8.4				
5/8/2004	0930	17.5	8.8				
5/8/2004	1130			10.4	10.4		
5/10/2004	0845	18.8	8.4	0.8		0.8	2f

M/F	45/30	12 ft tank			LHRH 150ug pellets		
Start Date	5/6/2004	1100					
End Date	5/10/2004	1100					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/6/2004	1240	18.4	6.6				
5/7/2004	1220	18	8.7				
5/8/2004	0930	17.2	8.8				
5/8/2004	1100			7.6	7.6		
5/10/2004	0815	18.8	8.4	0.4		0.4	3f

Trial No. 5

M/F	28/20	10 ft tank			LHRH 150ug pellets		
Start Date	5/11/2004	1200					
End Date	5/13/2004	1130					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/11/2004	1200	20.2	7.6				
5/12/2004	0725	20	8.2				
5/12/2004	1400	21.8	7.8				
5/13/2004	0735	21.5	8.9				
5/13/2004	1130			6.2	6.2		3f

Appendix Table A-2

Continued.

Trial No. 6

M/F	30/20	10 ft tank			LHRH 150ug pellets		
Start Date	5/13/2004	1230					
End Date	5/16/2004	0930					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/13/2004	1535	21.9	9.1				
5/14/2004	0735	22	8.6				
5/14/2004	1515	22.5	9.2				
5/15/2004	0930	22.9	7.3				
5/15/2004	1030			4.4	4.4		2f,1m
M/F	45/30	12 ft tank			LHRH 150ug pellets		
Start Date	5/13/2004	1100					
End Date	5/16/2004	930					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/13/2004	1535	21.9	8.2				
5/14/2004	0735	22	8.3				
5/14/2004	1515	22.8	8.8				
5/15/2004	0930	23	6.7				
5/15/2004	1000			10	10		13f,5m

Trial No. 7

M/F	30/20	10 ft tank			LHRH 150ug pellets		
Start Date	5/16/2004						
End Date	5/17/2004	0800	Water supply lost at 0100 AM				
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/16/2004	1245	24.0	9.7				
5/17/2004	0750	23.5	3.6	0	0		30m,20f
M/F	45/30	12 ft tank			LHRH 150ug pellets		
Start Date	5/16/2004	1130					
End Date	5/17/2004	800	Water supply lost at 0100 AM				
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/16/2004	1245	24.5	5.8				
5/17/2004	0750	23.5	3	0	0		45m,30f

Appendix Table A-2

Continued.

Trial No. 8

M/F	30/20	10 ft tank			LHRH 150ug pellets		
Start Date	5/18/2004	0930					
End Date	5/20/2004	0800					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/18/2004	1420	24.6	7.6				
5/19/2004	0800	24.1	7.4				
5/19/2004	1455	24.6	7.4				
5/20/2004	0800	23.4	6.6	1	1		6f,3m

M/F	45/30	12 ft tank			LHRH 150ug pellets		
Start Date	5/18/2018	1015					
End Date	5/20/2004	0830					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/18/2004	1420	24.6	6.8				
5/19/2004	0800	24.1	7.4				
5/19/2004	1455	24.6	6.4				
5/20/2004	0800	23.4	6	3.5	3.5		6f,2m

Trial No. 9

M/F	34/20	10 ft tank			LHRH 150ug pellets		
Start Date	5/20/2004	0940					
End Date	5/23/2004	1400					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/20/2004	1430	23.5	5.6				
5/21/2004	0730	23.2	6.1				
5/21/2004	1552	24	6.5				
5/22/2004	0755	23.3	5.8				
5/22/004	0830			0.9		0.9	
5/23/2004	1400						12f, 5m

M/F	45/30	12 ft tank			LHRH 150ug pellets		
Start Date	5/20/2004	1030					
End Date	5/23/2004	1400					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/20/2004	1430	23.5	5.8				
5/21/2004	0730	23.3	6.5				
5/21/2004	1552	24	7.0				
5/22/2004	0755	23.2	6.4				
5/22/2004	0830			3		3	
5/23/2004	1400						23f,1m

Appendix Table A-2

Continued.

Trial No. 10

M/F	33/20	10 ft tank			LHRH 150ug liquid		
Start Date	5/25/2004	0930					
End Date	5/27/2004						
Date	Time	Temp. (°C)	Oxygen ((ppm)	Eggs Collected	Eggs Shipped	River Releases	Morts Removed
5/25/2004	1630	26.1	6.1				
5/26/2004	0730	25.1	6.4				
5/26/2004	1540	25.5	6				1f
5/27/2004	0738	25.1	6.8	2.4		2.4	4f

Job II - Part 4

American Shad Egg Collection from the Lower Susquehanna River

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INTRODUCTION

For many years, the hatchery component of the Susquehanna River shad restoration program has relied on delivery of fertile shad eggs taken by strip-spawning of broodfish from the Hudson and Delaware rivers. Although Hudson River shad eggs have been extremely beneficial to the program with large numbers and very good viability, this is a costly project which involves hiring a private contractor and maintaining two netting crews over about a 30-day period each spring. Since the Susquehanna River adult shad population has grown substantially in recent years, SRAFRC is interested in using this egg source to eventually replace that of the Hudson River. This will reduce overall cost of egg collections while providing a genetically superior strain - fish with a demonstrated urge to return to the Susquehanna to spawn.

From the 1890s through about 1920, tens of millions of shad eggs were collected by commercial fishermen and delivered to U. S. Fish Commission culture operations at the head of the Chesapeake Bay near Havre de Grace, MD. Newly hatched larvae were released into nearby and distant waters but it was eventually determined that these stockings were not enhancing shad populations. In fact, Chesapeake Bay shad harvest levels declined sharply from the mid-1890's until about 1910. Maryland harvest stabilized at 1-2 million pounds per year during the 1920s through the early 1970s followed by a precipitous decline which led to Maryland's closure of all Bay fisheries in 1980.

Immediately prior to the recent crash of shad fisheries in the upper Bay, shad eggs were once again collected from the lower Susquehanna River near Lapidum, MD. In 1971-1973, over 20 million eggs were taken from this area and released into hatching boxes upstream of all Susquehanna dams. As this egg source declined it was replaced by other populations, including those of the Mattaponi, Pamunkey, Potomac, James and Columbia rivers which supplied eggs to the Susquehanna program through the early 1980s. The Hudson and Delaware rivers have been the program's primary egg producers since 1990.

The purpose of this effort in 2004 was to expand on initial investigations in 2003 which provided 555,000 shad eggs with 68% viability. The U. S. Fish and Wildlife Service (Harrisburg, PA and Annapolis, MD) assumed responsibility for this work.

METHODS

As was the case in 2003, commercial fisherman Gary "Rooster" Potter from Perryville, MD was hired on a daily rate basis to assist in brood fish collection, and to supply nets, storage facility and boat docks for the Service vessel. The USFWS Maryland Fishery Resources Office supplied a boat and 2-3 man crew and the Susquehanna River Coordinator provided most minor equipment (buckets, tubs, coolers, etc.) and directed daily operations. The plan called for netting shad three nights per week for 3-4 weeks during May, with eggs being delivered to Conowingo Dam nightly. Normandeau Associates, under separate contract to operate the tank spawning system at the dam, was responsible for delivery of eggs to Van Dyke. Normandeau also provided bottled oxygen from their supply at the dam.

Gear and Location

The primary gear employed for this effort included three multi-filament nets (mono is not allowed in MD), 500' and 700' in length and 12' deep with 5½" mesh and 500' x 12' with 5" mesh. The 5½" gear is the same as that used by Mr. Potter and his father for commercial shad fishing during the 1970s. The 5" mesh net was added this year in an effort to improve collection of bucks.

All netting attempts were initiated adjacent to the Lapidum boat landing in 12-15-ft of water approximately on the Harford-Cecil county line (Fig. 1). Length of drift time was limited by natural river flow, Conowingo operation, and placement of anchored catfish pots which had to be avoided to reduce gear damage. Sets at this location typically lasted for about 30 minutes, covered 1.0-1.5 km, and terminated off St. Catherine Island.

Effort

Netting and spawning operations occurred on seven nights between May 11-26. Spring 2004 was characterized as being of average river flow, but with a rapid rise of water temperature from 65 to 74°F between May 11-18. Fifteen net sets (1-3 per night) were completed (Table 1) with first sets each evening laid out about 8:00 p.m., fished for about 30 minutes, and reset. Operations usually ceased by about 11 p.m.

Egg Processing

Male and female shad pulled from nets were placed into separate wash tubs. Egg take proceeded immediately following capture using the dry pan method described by Wyatt Group and successfully employed in their Hudson River operation. After all eggs were taken from each individual set, sperm was squeezed from one to several ripe males, gametes were gently stirred and allowed to sit for 1-2 minutes. Clean river water was added to initiate fertilization and after a few minutes, the eggs were washed with clean water and placed into a large water-filled container to harden. The egg container was fitted with a surface aeration pump, and later, pure oxygen was added. Water-hardening lasted at least one hour.

Hardened eggs were strained through cheesecloth and packaged into double plastic bags, 5 liters of eggs with 5 liters of clean water, injected with oxygen and secured with rubber bands. Bags were placed into coolers and dropped off at Conowingo Dam for next day delivery to Van Dyke.

RESULTS

A total of 242 American shad were netted on seven nights including 83 bucks (mostly ripe), and 159 roe shad - about a 2:1 female to male ratio. Of the latter, 53 were green (hard roe), 38 were fully or mostly spent and the remaining 68 fish were ripe or only partially spent (Table 1). Other fish in collections included many gizzard shad and a few striped bass, channel catfish, blueback herring, hickory shad and carp. This year's collection compares to a 7- night effort in 2003 that produced 219 shad with a sex ratio of 6:1 favoring females.

Shad eggs were collected on six of seven nights but deliveries were made to Van Dyke only on three occasions: 2.5 liters on 5/11; 7.5 liters on 5/12; and 10.8 liters on 5/13. Eggs taken on May 18-20 and totaling about 8 liters were dumped because of very poor fertilization rates. No eggs were collected on May 26, the final night of operations.

A total of 752,700 shad eggs were shipped to Van Dyke of which 314,000 were viable (42%). This compared to 555,000 eggs shipped in 2003 with 68% viable. Viability for the three shipments ranged from 29% to 51%. Egg size was comparable to other rivers and averaged 36,200 eggs/liter. Surviving larvae were specially marked and stocked (see Job III).

DISCUSSION

Daily river flows during the May 2004 collecting period were considered average ranging between about 40,000 and 70,000 cfs. However, water temperatures were above average

beginning at 65°F on May 11 and rising to 75°F by May 28. The relatively good egg collections made during the first week are attributable to a high ratio of bucks and ideal water temperature of 65-68°F. During the second week, when water temperature rose to 72-74°F, 28 ripe females produced about 8 liters of eggs but only 8 males were collected and fertilization was extremely poor. On the final collecting date, May 26, only 4 roe shad (2 spent and 2 ripe) and one buck were taken. Nets were clogged with spawning gizzard shad that night and operations were terminated for the season.

Total catch per effort dropped off dramatically as water temperature warmed - from 19 shad per set on 5/11-13 to only 5 per set on 5/26. Abundance of males fell off at about the same rate from 8 per set to less than 2. Unusually cool water conditions in 2003 (60-63°F) produced similar results (555,000 eggs) but with higher viability. Future efforts at Lapidum must be coordinated to take advantage of best water temperatures in the range of 60-68°F whenever Conowingo operations allow adequate drift times.

Having an experienced commercial fisherman aboard each night was invaluable. His knowledge of the river and netting skills saved considerable time and effort in locating American shad. As was the case in 2003, shad were collected in every one of the 15 net sets during this operation. The 5-inch mesh net was used on only 2 occasions during the first week and was abandoned as it caught too many bucks - 63 of 124 fish on 5/11-12. In retrospect this gear should have probably been brought back the next week when buck numbers were low.

Overall roe to buck ratio for the season was 2:1. This would be sufficient for quality egg collection, but abundance of buck shad varied greatly as temperatures warmed. They were plentiful (almost 1:1 ratio) on May 11-13 when most eggs were taken and all Van Dyke deliveries were made, but very poorly represented in the catch (7:1 females) on all other dates.

Using Fish and Wildlife Service labor and boat, and contracting with an experienced fisherman, was a cost effective way to examine the possibility of taking shad eggs from the lower Susquehanna River. Shad catch, egg production and viability was hampered by cool and rainy weather in 2003, and by rapid river warming in 2004. Total cost of this operation to SRAFRC in 2004 was less than $3,000.

RECOMMENDATIONS

1. If continued, this effort should be expanded to include up to 15 nights of netting when water temperatures are in the range of 60-70°F. Weekends should be avoided due to heavy recreational boating use in the area around Lapidum.

2. A commercial fisherman should be contracted to assist as in 2003-2004. Ideally that person will supply properly hung shad nets, storage and boat dock space.

3. Lapidum should remain the primary netting site, but new areas such as between the I-95 and US 40 bridges and the Susquehanna Flats (north and south channel) should be more thoroughly investigated, perhaps by a second boat crew.

4. In addition to the 5½" roe net, the 5" buck net must be used to assure that adequate sperm is available for fertilization, especially later in the season.

5. Continue using the dry method of fertilization as well as traditional water-hardening and packaging techniques, but investigate used of pure oxygen during water hardening.

6. Deliver shad eggs nightly to Conowingo for later delivery to Van Dyke. If this is not viable (e.g., if Normandeau discontinued tank spawning), arrange for separate daily delivery.

ACKNOWLEDGMENTS

Appreciation is extended to the entire crew from USFWS Maryland Fishery Resources Office. Mike, Tina, Clif, Steve and Sheila put in 12-16 hour days in adding this nighttime work to their already busy day schedules. A special thanks is given to Rooster Potter for his always helpful attitude and especially for repeatedly putting us onto fish and mending torn nets.

Table 1. Shad Egg Collections from Lapidum, MD, lower Susquehanna River - 2004

Date	No. sets	Gear	Water temp. (°F)	Shad catch males	ripe roe	hard roe	spent	Eggs taken
May 11	3	500' x 5"	65	33	6	5	10	2.5 liters
May 12	3	500' x 5"/5½"	66	30	13	17	10	7.5 L
May 13	3	500' x 5 ½"	68	11	19	10	3	10.8 L
May 18	1	700' x 5 ½"	74	3	12	3	3	3 liters (dumped)
May 19	3	700' x 5 ½"	73	5	11	15	6	3 L "
May 20	1	700' x 5 ½"	72	0	5	3	4	2 L "
May 26	1	700' x 5 ½"	75	1	2	0	2	0
Totals	15			83	68	53	38	20.8 liters delivered

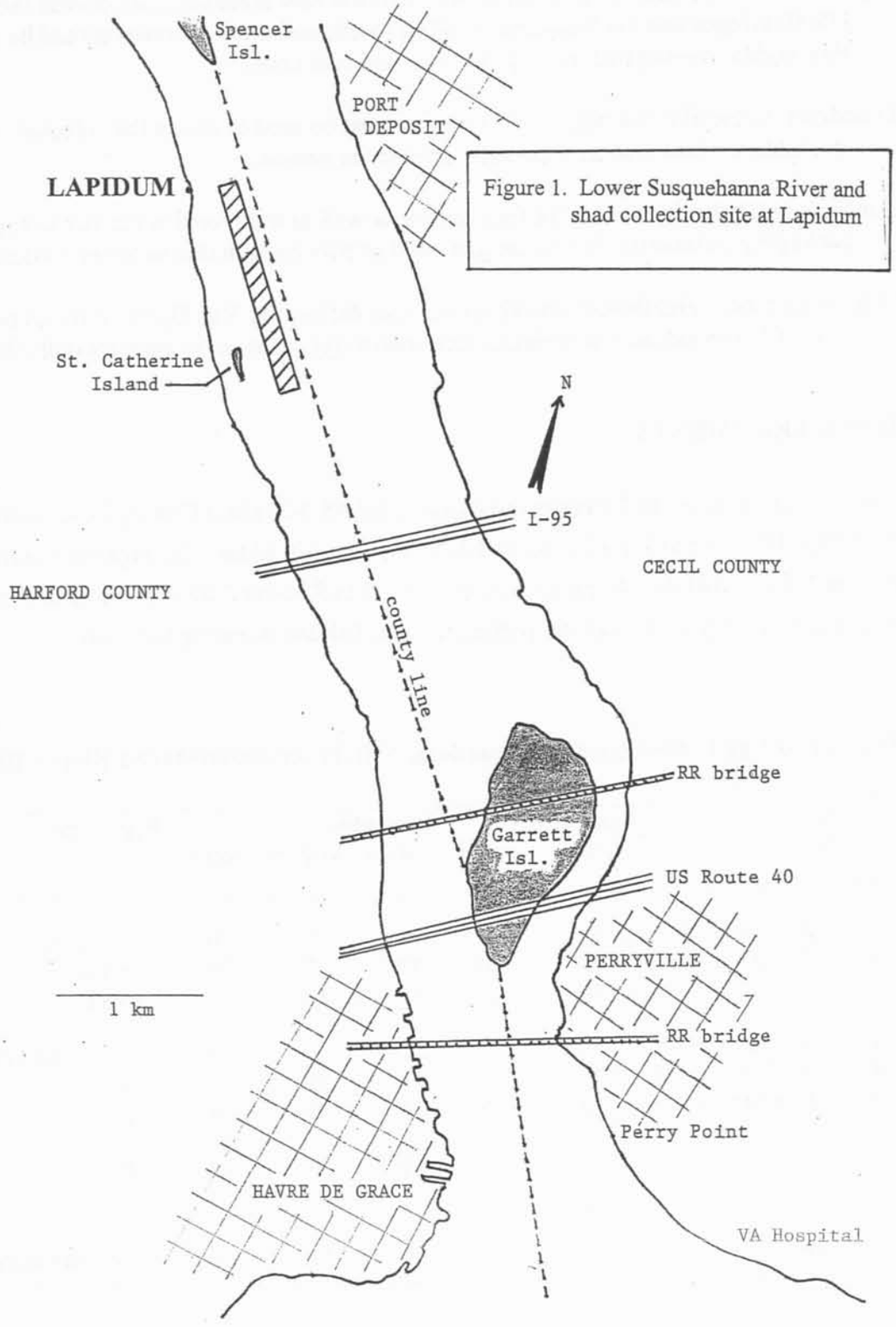

Figure 1. Lower Susquehanna River and shad collection site at Lapidum

JOB III. AMERICAN SHAD HATCHERY OPERATIONS, 2004

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INTRODUCTION

The Pennsylvania Fish and Boat Commission has operated the Van Dyke Research Station for Anadromous Fishes since 1976 as part of an effort to restore diadromous fishes to the Susquehanna River Basin. The objectives of the Van Dyke Station were to research culture techniques for American shad and to rear juveniles for release into the Juniata and Susquehanna rivers. The program goal was to develop a stock of shad imprinted to the Susquehanna drainage, which will subsequently return to the river as spawning adults. With the completion of York Haven Dam fish passage facilities in 2000, upstream hydroelectric project owners were no longer responsible for funding the hatchery effort. Funding was provided by the PA Fish and Boat Commission.

In 2003, a new effort in migratory fish restoration was undertaken. Adult hickory shad (*Alosa mediocris*) were collected and tank-spawned as part of the initial efforts to culture, release and restore runs of hickory shad to the Susquehanna and Delaware River basins.

As is previous years, production goals for American shad for 2004 were to stock 10-20 million American shad larvae. All Van Dyke hatchery-reared American and hickory shad larvae were marked by immersion in tetracycline bath treatments in order to distinguish hatchery-reared shad from those produced by natural spawning of wild adults. All eggs received at Van Dyke were disinfected to prevent the spread of infectious diseases from out-of-basin sources.

EGG SHIPMENTS

Hickory shad

A total of 13.6 million hickory shad eggs (33.4 L) were received in four shipments

from tank-spawning operations at Conowingo Dam (Table 1). Some 6.2 million (46.1%) of the hickory shad eggs were viable.

American shad

A total of 17.3 million American shad eggs (462 L) were received in 43 shipments in 2004 (Table 1). This was the second lowest quantity of eggs received since 1982 (Table 2). Poor spawning runs on the Hudson and Delaware River, coupled with rapidly increasing water temperatures which truncated the spawning period were responsible for the reduction in egg collection success. Overall American shad egg viability (which we define as the percentage which ultimately hatches) was 54.0%.

Sixteen Hudson River egg shipments (9.4 million eggs) were received from May 3 to May 23, 2004. Overall viability was 74.9%. By comparison, in 2003, 23 shipments were received from the Hudson River for a total of 17.1 million eggs. Hudson River eggs were collected only from the site at Coxsackie, where water depths permit gill netting at all stages of the tide.

Delaware River egg shipments were received from May 10 to May 28. A total of 13 shipments were received (2.4 million eggs) with a viability of 43.0%. By comparison, in 2003, the Delaware River produced 3.6 million eggs.

The U.S. Fish and Wildlife Service obtained eggs by strip-spawning ripe adult shad collected by gill net in the lower Susquehanna River near Lapidum MD. Three shipments were received (20.8L) between May 12 and May 14. A total of 752 thousand eggs were received with a viability of 41.7%.

Normandeau Associates, under contract with the PFBC, attempted to obtain eggs by strip-spawning ripe adult shad collected by gill net in the upper portion of Conowingo Reservoir. Few ripe shad were collected and no eggs were shipped.

American shad eggs were also obtained from a tank-spawning effort at Conowingo Dam, operated by Normandeau Associates. Pre-spawn adult American shad were

obtained from the West Fish Lift at Conowingo Dam, injected with hormones and allowed to spawn naturally. Some 4.7 million eggs, in 7 shipments, were delivered to the Van Dyke Hatchery, with a viability of 20.0%. By comparison, 11.7 million eggs, in 14 shipments, were received from this source in 2003. Rapidly increasing water temperatures negatively impacted tank-spawning efforts at Conowingo Dam.

SURVIVAL

Overall survival of American shad larvae was 60% compared to a range of 19% to 94% for the period 1984 through 2003. The 18% decline in survival from 2003 (78%) was due, in part, to rearing the larvae longer, while waiting for river flows and turbidity to decrease. Average age at stocking was 23.4 days in 2004, compared to 19.5 days in 2003. In addition, nearly complete mortality occurred in tanks E11 and H21 (Figure 1). The mortality episode in E11 occurred at 10-d of age when a piece of fiberglass insulation fell out of the loft and lodged in the influent valve, shutting off flow and resulted in nearly complete mortality of the 300,000 larvae in the tank. Tank H21 suffered nearly complete mortality immediately after hatch. The tank received an MSXXX jar with 350,000 eggs from shipment 36, a tank-spawn shipment. Only 13% (45,000) of the eggs were viable and, because the dead did not layer, they could not be siphoned off. The larvae hatched on schedule, after sunning, but could not exit the jar due to the large number of overlying dead eggs. Live larvae could be seen struggling to swim up against the weight of the large volume of dead eggs. So few live larvae remained after a few days of culture that they were ultimately discarded.

Survival of individual tanks followed patterns similar to those observed in the past. Fifteen tanks, reared from 26 to 42 days of age, exhibited 26-d survival of 63% (Figure 1). Seven tanks, reared from 17 to 21 days of age, exhibited 17-d survival of 75%. Two tanks, reared from 9 to 11 days of age, exhibited 9-d survival of 92%. As was typical of mortality patterns experienced in the past, mortality increased at about 11 days of age. Tanks E11 and H21 exhibited nearly complete mortality as explained above (Figure 1). Four tanks of larvae were partially stocked to relieve crowding in the tank. High densities (330 to 604 thousand larvae) were cultured in these tanks in anticipation of abundant egg

deliveries, which never materialized. Survival of these four tanks of larvae is plotted separately (Figure 2).

LARVAL PRODUCTION

Hickory shad larvae (3.4 million) were stocked in the lower Susquehanna River at Muddy Creek Access in the Conowingo Reservoir. Some 2.7 million hickory shad were also stocked in the Delaware River (1.8 million) and its tributaries, Pennypack Creek (667 thousand) and Ridley Creek (267 thousand).

Production and stocking of American shad larvae, summarized in Tables 2, 3 and 4, totaled 5.67 million. A total of 2.6 million was released in the Juniata River, 283 thousand in the Susquehanna River near Montgomery Ferry, 485 thousand in the North Branch Susquehanna River in New York, 343 thousand in the Chemung River in New York, 480 thousand in the North Branch Susquehanna River in Pennsylvania, and 282 thousand in the West Branch Susquehanna River. American shad larvae were also stocked in tributaries: 200 in Conodoguinet Creek, 60 thousand in the Conestoga River, 142 thousand in West Conewago Creek and 53 thousand in Swatara Creek. In addition, 366 thousand larvae were stocked in the Lehigh River, 422 thousand were stocked in the Schuylkill River, and 119 thousand were provided to New Jersey Division of Fish and Wildlife to support restoration efforts in the Raritan River.

TETRACYCLINE MARKING

All American and hickory shad larvae produced at Van Dyke received marks produced by immersion in tetracycline (Table 5). Immersion marks were administered by bath treatments in 256-ppm oxytetracycline hydrochloride for 4h duration. All hickory shad larvae were marked with a single mark on day 3, while all American shad larvae were marked according to stocking site and/or egg source. American shad larvae from the Susquehanna River egg source, and stocked in the Juniata River or Susquehanna River near Montgomery Ferry were given a triple mark at 3, 6, and 9 days of age. Larvae from out-of-basin egg sources and stocked in the Juniata River or Susquehanna River near Montgomery Ferry were marked at 3, 9 and 12 days of age. Larvae stocked in the Conodoguinet Creek were given a quadruple mark at 3, 6, 12 and 15 days of age.

Larvae stocked in the Conestoga River were given a quadruple mark at 3, 9, 12, and 15 days of age. Larvae stocked in Swatara Creek were given a quintuple mark at 3, 6, 9, 15, and 18 days of age. Larvae stocked in West Conewago Creek were given a quintuple mark at 3, 9, 12, 15 and 18 days of age. Larvae stocked in the North Branch Susquehanna River (NY) were given a quintuple mark at 3, 6, 9, 12, and 18 days of age. Larvae stocked in the Chemung River (NY) were given a triple mark at 3, 15 and 18 days of age. Larvae stocked in the North Branch Susquehanna River (PA) were given a quadruple mark at 3, 6, 9, and 15 days of age. Larvae stocked in the Lehigh River were given a triple mark at 9, 12, and 15 days of age. Larvae stocked in the Schuylkill River were given a quadruple mark at 3, 6, 9, and 12 days of age. Larvae provided to New Jersey Division of Fish and Wildlife for the Raritan River were given a single mark at 3 days of age.

Verification of mark retention was accomplished by stocking groups of marked fry in raceways and examining otolith samples collected later. Otoliths were extracted and mounted in Permount on microscope slides. A thin section was produced by grinding the otolith on both sides. Otolith sections were examined for marks with an epi-fluorescent microscope with a UV light source. Retention of tetracycline marks for American shad was 100% for all groups analyzed (Table 5). No fish from Tank E11 were analyzed for marks due to the high mortality in the tank (see discussion above). All surviving larvae in this tank (200) were stocked in Conodoguinet Creek; none were transferred to raceways for mark retention studies.

Only 1 of 20 (5%) of the hickory shad otoliths examined exhibited marks. In 2003, 15% of the hickory shad were marked. The cause of this poor marking success is unknown. In 2005, we will attempt to mark hickory shad larvae at a higher OTC concentration (400ppm). Analysis of survival of each uniquely marked group is discussed in Appendix II.

SUMMARY

Four shipments of hickory shad eggs (13.6 million eggs) were received at Van Dyke in 2004. Egg viability was 46.1% and 6.25 million hickory shad larvae were stocked

in Conowingo Reservoir and in the Delaware River and its tributaries, Pennypack Creek and Ridley Creek.

A total of 39 shipments of American shad eggs (17.3 million eggs) was received at Van Dyke in 2004. Total egg viability was 54% and survival of viable eggs to stocking was 60%, resulting in production of 5.6 million larvae. Larvae were stocked in the Juniata River (2.6 million), Susquehanna River near Montgomery Ferry (280 thousand), Conodoguinet Cr. (200), Conestoga River (60 thousand), Swatara Creek (53 thousand), West Conewago Cr. (142 thousand), the North Branch Susquehanna River, NY (485 thousand), the Chemung River, NY (343 thousand), the North Branch Susquehanna River, PA (480 thousand), the West Branch Susquehanna River (282 thousand), the Lehigh River (366 thousand), the Schuylkill River (422 thousand) and the Raritan River in New Jersey (119 thousand).

Overall survival of larvae was 60%. Problems with mortality associated with foam bottom screens did not re-occur in 2004. High, turbid water postponed stocking and contributed to additional mortality while larvae waited in the hatchery for river conditions to subside.

All American and hickory shad larvae cultured at Van Dyke were marked by 4-hour immersion in 256 ppm oxytetracycline. Marks for American shad were assigned based on release site and/or egg source river. Mark retention for American shad was 100% for all groups analyzed. Hickory shad were marked on day three. Mark retention for hickory shad was 5%.

RECOMMENDATIONS FOR 2005

1. Disinfect all egg shipments at 50 ppm free iodine.
2. Slow temper eggs collected at river temperatures below 55°F.
3. Routinely feed all larvae beginning at hatch.
4. Continue to hold egg jars on the incubation battery until eggs begin hatching (usually day 7), before transferring to the tanks. Transfer incubation jars to the tanks on day 7 without sunning. Sun the eggs on day 8 to force hatching.

5. Continue to siphon eggshells from the rearing tank within hours of egg hatch.
6. Continue to feed left over AP-100 only if freshly manufactured supplies run out.
7. Continue to hold Delaware River eggs until 8:00AM before processing.
8. Buy new foam bottom screens each year and specify "no-fire retardants" when ordering foam.
9. Modify the egg battery to accept 23 additional MSXXX jars (total 57).
10. Continue to develop a reference collection of scales and otoliths from known age American shad by marking according to year stocked (Table 6). Utilize larvae from the Hudson River egg source, stocked in the Juniata or Susquehanna Rivers, and uniquely marked on a three year rotating schedule.
11. Mark hickory shad at 400ppm OTC.

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Figure 1. Survival of selected tanks of American shad larvae, Van Dyke, 2004.

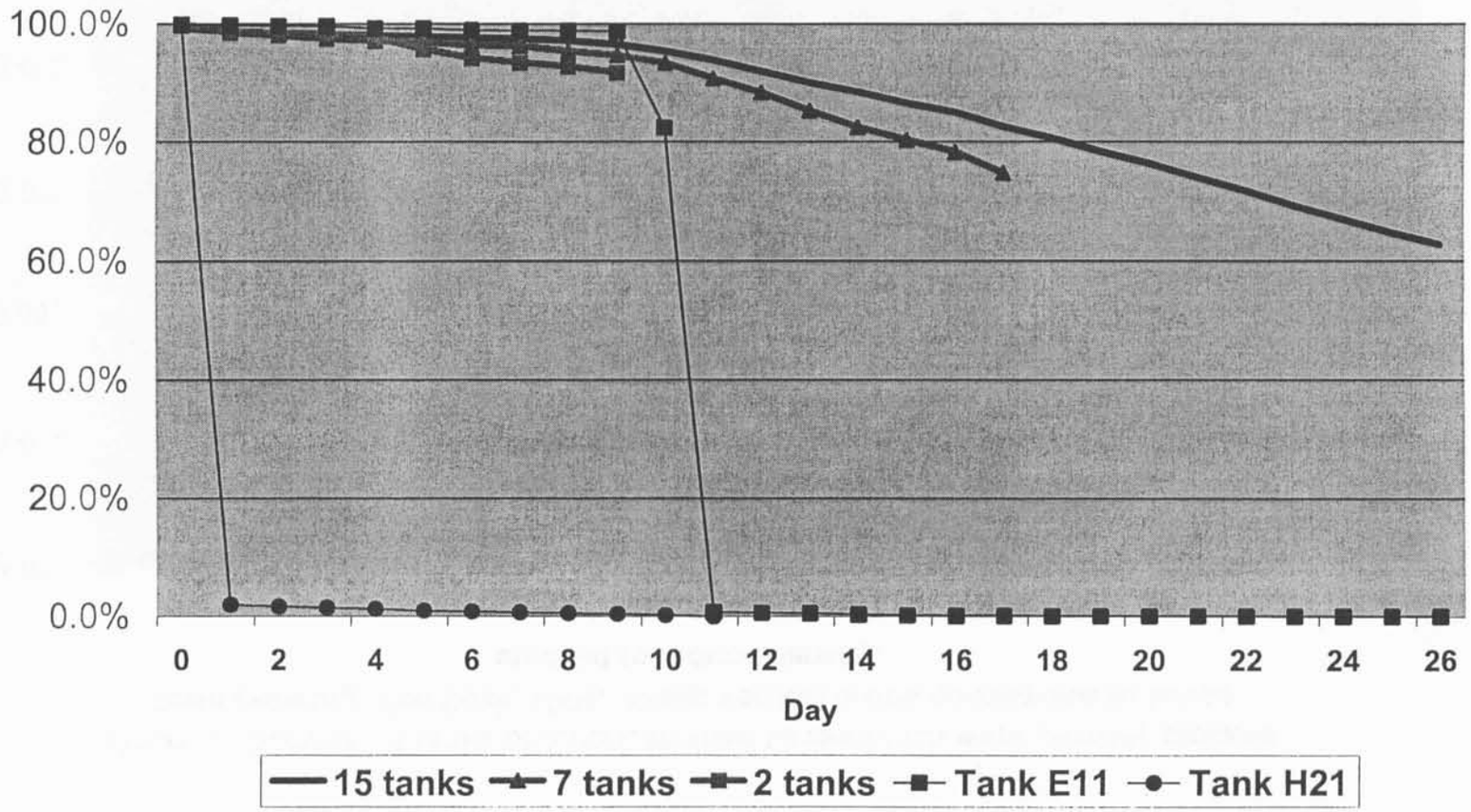

Figure 2. Survival of tanks of American shad larvae which were partially stocked during rearing, Van Dyke, 2004. Steep vertical drops correspond to larvae stocked to reduce density.

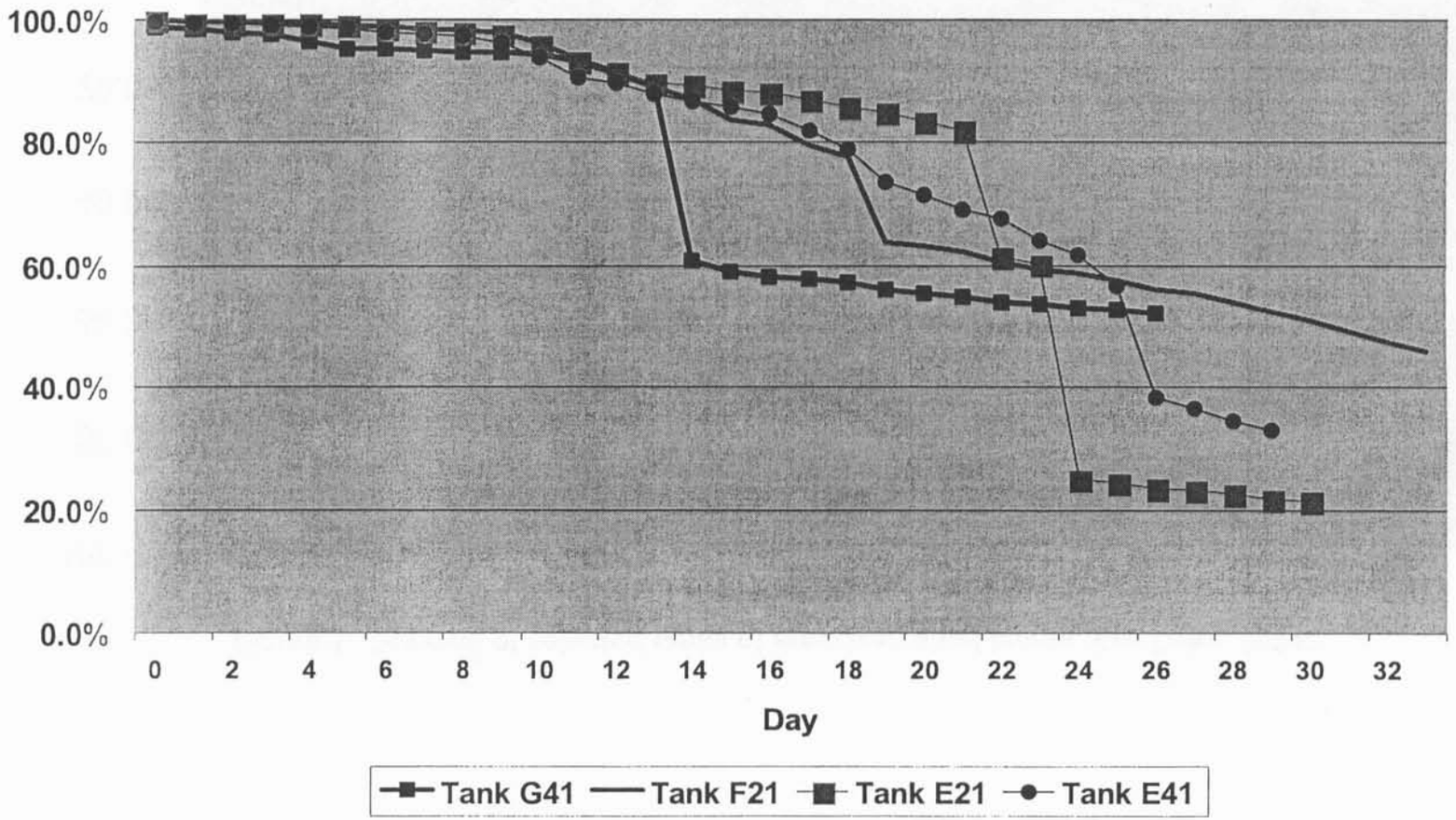

Table 1. Egg shipments received at Van Dyke, 2004.

No.	Species	River	Date Spawned	Date Received	Volume (L)	Eggs	Viable Eggs	Percent Viable
1	HS	Susq.-Con.	4/21/04	4/21/04	18.9	7,010,347	2,018,110	28.8%
2	HS	Susq.-Con.	4/22/04	4/22/04	11.9	5,485,613	3,475,002	63.3%
3	HS	Susq.-Con.	4/25/04	4/25/04	1.3	516,419	490,512	95.0%
4	HS	Susq.-Con.	4/25/04	4/25/04	1.3	543,126	261,635	48.2%
5	AS	Susq.-Con.	4/29/04	4/29/04	17.8	1,130,537	305,483	27.0%
6	AS	Susq.-Con.	5/1/04	5/1/04	6.6	383,883	110,945	28.9%
7	AS	Hudson	5/2/04	5/3/04	19.6	652,687	465,890	71.4%
8	AS	Hudson	5/3/04	5/4/04	18.8	561,114	180,219	32.1%
9	AS	Hudson	5/4/04	5/5/04	27.2	886,431	498,742	56.3%
10	AS	Hudson	5/5/04	5/6/04	34.9	1,053,303	793,053	75.3%
11	AS	Susq.-Con.	5/6/04	5/6/04	13.4	751,892	87,050	11.6%
12	AS	Hudson	5/6/04	5/7/04	15.0	452,709	365,538	80.7%
13	AS	Susq.-Con.	5/8/04	5/8/04	16.8	812,844	163,829	20.2%
14	AS	Hudson	5/8/04	5/9/04	45.8	1,541,616	1,212,151	78.6%
15	AS	Delaware	5/9/04	5/10/04	4.3	135,630	52,283	38.5%
16	AS	Hudson	5/9/04	5/10/04	29.7	773,023	558,629	72.3%
17	AS	Delaware	5/10/04	5/11/04	1.2	34,242	18,738	54.7%
18	AS	Hudson	5/10/04	5/11/04	3.5	105,632	83,771	79.3%
19	AS	Delaware	5/11/04	5/12/04	2.4	71,632	33,206	46.4%
20	AS	Hudson	5/11/04	5/12/04	15.1	445,675	398,164	89.3%
21	AS	Susq.-Lap.	5/12/04	5/12/04	2.5	79,721	27,914	35.0%
22	AS	Susq.-Lap.	5/13/04	5/13/04	7.5	260,650	76,381	29.3%
23	AS	Susq.-Con.	5/13/04	5/13/04	5.8	436,021	123,016	28.2%
24	AS	Hudson	5/13/04	5/14/04	28.2	919,020	780,937	85.0%
25	AS	Susq.-Lap.	5/14/04	5/14/04	10.8	412,296	209,841	50.9%
26	AS	Susq.-Con.	5/15/04	5/15/04	14.4	875,512	115,097	13.1%
27	AS	Hudson	5/15/04	5/16/04	19.3	514,154	477,082	92.8%
28	AS	Delaware	5/16/04	5/17/04	8.7	226,441	141,849	62.6%
29	AS	Hudson	5/16/04	5/17/04	16.9	556,747	473,404	85.0%
30	AS	Delaware	5/17/04	5/18/04	2.1	66,966	24,144	36.1%
31	AS	Hudson	5/17/04	5/18/04	8.8	293,043	236,176	80.6%
32	AS	Delaware	5/18/04	5/19/04	8.6	289,474	231,390	79.9%
33	AS	Hudson	5/18/04	5/19/04	8.0	280,984	217,225	77.3%
34	AS	Delaware	5/19/04	5/20/04	7.2	250,224	175,550	70.2%
35	AS	Hudson	5/19/04	5/20/04	5.2	184,576	150,563	81.6%
36	AS	Susq.-Con.	5/20/04	5/20/04	4.5	349,506	44,656	12.8%
37	AS	Delaware	5/20/04	5/21/04	3.9	120,339	66,283	55.1%
38	AS	Hudson	5/22/04	5/23/04	5.5	169,709	138,679	81.7%
39	AS	Delaware	5/23/04	5/24/04	6.2	335,467	56,608	16.9%
40	AS	Delaware	5/24/04	5/25/04	7.0	456,258	85,352	18.7%

Table 1. (continued).

No.	Species	River	Date Spawned	Date Received	Volume (L)	Eggs	Viable Eggs	Percent Viable
41	AS	Delaware	5/25/04	5/26/04	2.8	170,238	18,207	10.7%
42	AS	Delaware	5/26/04	5/27/04	4.4	200,990	96,164	47.8%
43	AS	Delaware	5/27/04	5/28/04	1.5	48,884	35,224	72.1%
Totals				No. of shipments				
	AS	Hudson		16	301.5	9,390,423	7,030,223	74.9%
		Delaware		13	60.3	2,406,785	1,034,998	43.0%
		Susq.-Conowingo		7	79.3	4,740,195	950,074	20.0%
		Susq.-Lapidum		3	20.8	752,667	314,135	41.7%
		Susq.-Muddy Run						
		Total		39	461.9	17,290,070	9,329,431	54.0%
	HS	Susq.Conowingo		4	33.4	13,555,506	6,245,258	46.1%

HS- Hickory shad
AS- American shad

Table 2. Annual summary of American shad production in the Susquehanna River Basin, 1976-2004.

Year	Egg Vol. (L)	No. of Eggs (exp.6)	Egg Via-bility (%)	No. of Viable Eggs (exp.6)	No. of Fry stocked (exp.3)	No. of Finglerling stocked (exp.3)	Total stocked (exp.3)	Fish Stocked/ Eggs Rec'd	Fish Stocked/ Viable Eggs
1976	120	4.0	52.0	2.1	518	266	784	0.19	0.37
1977	145	6.4	46.7	2.9	969	35	1,003	0.16	0.34
1978	381	14.5	44.0	6.4	2,124	6	2,130	0.10	0.33
1979	164	6.4	41.4	2.6	629	34	664	0.10	0.25
1980	347	12.6	65.6	8.2	3,526	5	3,531	0.28	0.43
1981	286	11.6	44.9	5.2	2,030	24	2,053	0.18	0.39
1982	624	25.9	35.7	9.2	5,019	41	5,060	0.20	0.55
1983	938	34.5	55.6	19.2	4,048	98	4,146	0.12	0.22
1984	1157	41.1	45.2	18.6	11,996	30	12,026	-	0.73
1985	814	25.6	40.9	10.1	6,960	115	7,075	0.28	0.68
1986	1535	52.7	40.7	21.4	15,876	61	15,928	0.30	0.74
1987	974	33.0	40.7	15.8	10,274	81	10,355	0.31	0.66
1988	885	31.8	38.7	12.3	10,441	74	10,515	0.33	0.86
1989	1220	42.7	60.1	25.7	22,267	60	22,327	0.52	0.87
1990	896	28.6	56.7	16.2	12,034	253	12,287	0.43	0.76
1991	902	29.8	60.7	18.1	12,963	233	13,196	0.44	0.73
1992	532	18.5	68.3	12.6	4,645	34	4,679	0.25	0.37
1993	558	21.5	58.3	12.8	7,870	79	7,949	0.37	0.62
1994	551	21.2	45.9	9.7	7,720 *	140	7,860	0.31	0.68
1995	768	22.6	53.9	12.2	10,930 *	-	10,930	0.43	0.79

Table 2. (continued).

Year	Egg Vol. (L)	No. of Eggs (exp.6)	Egg Via-bility (%)	No. of Viable Eggs (exp.6)	No. of Fry stocked (exp.3)	No. of Finglerling stocked (exp.3)	Total stocked (exp.3)	Fish Stocked/ Eggs Rec'd	Fish Stocked/ Viable Eggs
1996	460	14.4	62.7	9.0	8,466 *	-	8,466	0.59	0.94
1997	593	22.8	46.6	10.6	8,019	25	8,044	0.35	0.76
1998	628	27.7	57.4	15.9	11,757	2	11,759	0.42	0.74
1999	700	26.6	59.2	15.7	14,412	-	14,412	0.54	0.92
2000	503	18.7	64.8	12.1	10,535	-	10,535	0.56	0.87
2001	423	21.1	35.0	7.4	6,524	7	6,531	0.31	0.88
2002	943	35.6	38.8	13.8	2,589	-	2,589	0.07	0.19
2003	1005	33.0	49.4	16.3	12,742	-	12,742	0.39	0.78
2004	462	17.3	54.0	9.3	5,637	-	5,637	0.33	0.60
*Includes fry reared at Manning Hatchery.						Total	235,212		
						Total since 1985 (OTC marked)	203,815		

Table 3. American shad stocking and fish transfer activities, 2004.

Date	Tank		Species	Number	Location	OTC mark (days)	Origin	Age	Size
5/3/04	A1	1	HS	984,448	Delaware River, Pennypack Cr., Ridley Cr.	3	Susq.	4	Fry
5/3/04	A2	1	HS	1,015,819	Delaware River, Pennypack Cr., Ridley Cr.	3	Susq.	4	Fry
5/4/04	A3	1	HS	3,366,573	Muddy Cr. Access Area	3	Susq.	4	Fry
5/5/04	A4	1	HS	748,891	Delaware River	3	Susq.	5	Fry
5/17/04	B1	1	AS	250,000	Huntingdon	3,6,9	Susq.	10	Fry
6/8/04	B2	1	AS	71,919	Huntingdon	3,9,12	Hudson	28	Fry
6/8/04	B3	1	AS	151,349	Huntingdon	3,9,12	Hudson	28	Fry
6/8/04	B4	1	AS	108,847	Huntingdon	3,9,12	Hudson	27	Fry
6/24/04	C1	1	AS	60,273	Conestoga River	3,9,12,15	Hudson	42	Fry
6/3/04	C2	1	AS	183,000	N. Br. Susq. R. (NY)	3,6,9,12,18	Hudson	20	Fry
6/3/04	C3	1	AS	151,228	N. Br. Susq. R. (NY)	3,6,9,12,18	Hudson	20	Fry
6/24/04	C4	1	AS	53,261	Swatara Creek	3,6,9,15,18	Hudson	42	Fry
6/3/04	D1	1	AS	150,705	N. Br. Susq. R. (NY)	3,6,9,12,18	Hudson	20	Fry
6/10/04	D2	1	AS	120,362	Miller's Canoe Rental	3,6,9	Susq.	27	Fry
6/10/04	D3	1	AS	206,560	Miller's Canoe Rental	3,9,12	Hudson	26	Fry
6/24/04	D4	1	AS	142,155	West Conewago Creek	3,9,12,15,18	Hudson	38	Fry
6/24/04	E1	1	AS	200	Conodoguinet Creek	3,6,12,15	Hudson	38	Fry
6/7/04	E2	1	AS	100,000	Millerstown (Greenwood)	3,9,12	Hudson	21	Fry
6/9/04	E2	1	AS	200,000	Millerstown (Rt. 17)	3,9,12	Hudson	23	Fry
6/16/04	E2	1	AS	124,777	Thompsontown	3,9,12	Hudson	31	Fry
6/21/04	E3	1	AS	54,766	Lehigh River	9,12,15	Delaware	33	Fry
6/12/04	E4	1	AS	50,000	Clark's Ferry	3,9,12	Hudson	25	Fry
6/16/04	E4	1	AS	108,489	Montgomery Ferry	3,9,12	Hudson	29	Fry
6/16/04	F1	1	AS	151,655	Thompsontown	3,9,12	Hudson	29	Fry
6/7/04	F2	1	AS	60,000	Millerstown (Greenwood)	3,9,12	Hudson	19	Fry
6/22/04	F2	1	AS	234,389	Mexico	3,9,12	Hudson	33	Fry
6/7/04	F3	1	AS	7,000	Millerstown (Greenwood)	3,6,9	Susq.	19	Fry
6/22/04	F3	1	AS	463,213	Mifflin	3,6,9	Susq.	32	Fry
6/17/04	F4	1	AS	479,805	North Br. Susq. R. (PA)	3,6,9,15	Hudson	27	Fry
6/10/04	G1	1	AS	282,143	West Br. Susq. R.	3,6,9,12,15	Hudson	17	Fry
6/21/04	G2	1	AS	73,450	Lehigh River	9,12,15	Delaware	27	Fry
6/15/04	G3	1	AS	343,253	Chemung River	3,15,18	Hudson	21	Fry
6/9/04	G4	1	AS	160,000	Millerstown (Rt. 17)	3,9,12	Hudson	13	Fry
6/22/04	G4	1	AS	315,384	Mifflin	3,9,12	Hudson	26	Fry
6/15/04	H1	1	AS	421,583	Schuylkill River	3,6,9,12	Delaware	18	Fry
	H2	1	AS	All dead!!!		3,6,9	Susq.		
6/9/04	H3	1	AS	118,888	Raritan River	3	Hudson	9	Fry
6/21/04	H4	1	AS	238,199	Lehigh River	9,12,15	Delaware	19	Fry

Table 4. Production and utilization of juvenile Alosids, Van Dyke, 2004.

	Site		Fry
American shad Releases	Millerstown (Greenwood)		167,000
	Millerstown (Rt. 17 Bridge)		360,000
	Miller's Canoe Rental		326,921
	Thompsontown		151,655
	Mexico		315,384
	Mifflin		697,602
	Huntingdon		582,115
		Juniata River Subtotal	2,600,678
	Clark'sFerry		50,000
	Montgomery Ferry		233,266
	Conodoguinet Creek		200
	Conestoga River		60,273
	Swatara Creek		53,261
	West Conewago Creek		142,155
	North Branch Susquehanna River (PA)		479,805
	West Banch Susquehanna River		282,143
	Chemung River		343,253
	North Branch Susquehanna River (NY)		484,933
		Susquehanna River Basin Subtotal	4,729,967
	Schuylkill River		421,583
	Lehigh River		366,414
	Raritan River		118,888
		Total American shad	**5,636,851**
Hickory shad releases	Muddy Creek Access Area		3,366,573
		Susquehanna River Basin Subtotal	3,366,573
	Delaware River		1,815,701
	Pennypack Cr.		666,755
	Ridley Creek		266,702
		Delaware River Basin Subtotal	2,749,158
		Total Hickory shad	**6,115,731**

Table 5. Summary of marked Alosines stocked in Pennsylvania, 2004.

Number	Size	Immersion Mark (days)	Feed Mark Feed	Immersion Tag	Feed Tag	Immersion Mark Retention (%)	Feed Mark Retention (%)	Fry Culture	Fingerling Culture	Stocking Location	Egg Source
American shad											
2,043,369	Fry	3,9,12	-	256ppm OTC	-	100%	-	Van Dyke	-	Juniata/Susq. R.	Hudson
840,575	Fry	3,6,9	-	256ppm OTC	-	100%	-	Van Dyke	-	Juniata/Susq. R.	Susquehanna
200	Fry	3,6,12,15	-	256ppm OTC	-	N/A	-	Van Dyke	-	Conodoguinet Cr.	Hudson
60,273	Fry	3,9,12,15	-	256ppm OTC	-	100%	-	Van Dyke	-	Conestoga R.	Hudson
142,155	Fry	3,9,12,15,18	-	256ppm OTC	-	100%	-	Van Dyke	-	W. Conewago Cr.	Hudson
53,261	Fry	3,6,9,15,18	-	256ppm OTC	-	100%	-	Van Dyke	-	Swatara Cr.	Hudson
282,143	Fry	3,6,9,12,15	-	256ppm OTC	-	100%	-	Van Dyke	-	W. Br. Susq. R.	Hudson
479,805	Fry	3,6,9,15	-	256ppm OTC	-	100%	-	Van Dyke	-	N. Br. Susq. R.(PA)	Hudson
484,933	Fry	3,6,9,12,18	-	256ppm OTC	-	100%	-	Van Dyke	-	N. Br. Susq. R.(NY)	Hudson
343,253	Fry	3,15,18	-	256ppm OTC	-	100%	-	Van Dyke	-	Chemung R. (NY)	Hudson
366,414	Fry	9,12,15	-	256ppm OTC	-	100%	-	Van Dyke	-	Lehigh R.	Delaware
421,583	Fry	3,6,9,12	-	256ppm OTC	-	100%	-	Van Dyke	-	Schuylkill R.	Delaware
118,888	Fry	3	-	256ppm OTC	-	100%	-	Van Dyke	-	Raritan R. (NJ)	Hudson
5,636,851	Fry	Total									
Hickory shad											
3,366,573	Fry	3	-	256ppm OTC	-	5.0%	-	Van Dyke	-	Conowingo Res.	Susquehanna
1,815,701	Fry	3	-	256ppm OTC	-	5.0%	-	Van Dyke	-	Delaware River	Susquehanna
266,702	Fry	3	-	256ppm OTC	-	5.0%	-	Van Dyke	-	Ridley Cr.*	Susquehanna
666,755	Fry	3	-	256ppm OTC	-	5.0%	-	Van Dyke	-	Pennypack Cr.*	Susquehanna
6,115,731	Fry	Total									

* Tributary to the Delaware River.

Table 6. Proposed marking plan for Alosines stocked in Pennsylvania, 2004-2009.

Size	Immersion mark (days)	Immersion mark	Stocking Location	Egg Source	Years
American shad					
Fry	3	256ppm OTC	Juniata/Susq. R.	Hudson	2006, 2009
Fry	3,9,12	256ppm OTC	Juniata/Susq. R.	Hudson	2004, 2007
Fry	3,6,12	256ppm OTC	Juniata/Susq. R.	Hudson	2005, 2008
Fry	3,6,9	256ppm OTC	Juniata/Susq. R.	Susquehanna	2004-2009
Fry	3,6,9,12,15	256ppm OTC	W. Br. Susq. R.	Hudson	2004-2009
Fry	3,6,12,15	256ppm OTC	Conodoguinet Cr.	Hudson	2004-2009
Fry	3,9,12,15	256ppm OTC	Conestoga R.	Hudson	2004-2009
Fry	3,9,12,15,18	256ppm OTC	W. Conewago Cr.	Hudson	2004-2009
Fry	3,6,9,15,18	256ppm OTC	Swatara Cr.	Hudson	2004-2009
Fry	3,6,9,15	256ppm OTC	N. Br. Susq. R.(PA)	Hudson	2004-2009
Fry	3,6,9,12,18	256ppm OTC	N. Br. Susq. R.(NY)	Hudson	2004-2009
Fry	3,15,18	256ppm OTC	Chemung R. (NY)	Hudson	2004-2009
Fry	9,12,15	256ppm OTC	Lehigh R.	Delaware	2004-2009
Fry	3,6,9,12	256ppm OTC	Schuylkill R.	Delaware	2004-2009
Fry	3	256ppm OTC	Raritan R. (NJ)	Hudson	2004-2009
Fry	3,6,12,15,18	256ppm OTC	Del. R. (Smithfield)	Delaware	2004-2009
Hickory shad					
Fry	3	256ppm OTC	Conowingo Res.	Susquehanna	2004-2009
Fry	3	256ppm OTC	Delaware River	Susquehanna	2004-2009
Fry	3	256ppm OTC	Ridley Cr.	Susquehanna	2004-2009
Fry	3	256ppm OTC	Pennypack Cr.	Susquehanna	2004-2009

Appendix 1

Survival of larvae from American shad eggs incubated in egg jars with foam bottom screens vs. aluminum bottom screens, Van Dyke, 2004

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Introduction

American shad eggs incubated at the Van Dyke Hatchery between 1976 and 1987 were incubated exclusively in May-Sloan incubation jars. In 1987, we constructed, and began testing homemade incubation jars that we named the "Van Dyke jar". Specifications of the May-Sloan and Van Dyke jars are listed in Table 1. While use of the Van Dyke jar increased egg battery capacity from 250L to 450L, using window screen as a bottom screen resulted in problems with dead spots (areas of reduced flow) in the jar. These dead spots resulted in mortality of fully developed, eyed eggs, which appeared to be dead fry in the jar (Hendricks et al. 1989).

In 1990, we began testing of open-cell foam as a bottom screen in Van Dyke jars. The advantage of the foam was the uniform flow through the eggs with no dead spots, and consequently no dead fry in the jar. Foam bottom screens were used in 25 production jars in 1991 with no dead fry observed in any of the jars (Hendricks et al. 1992).

As a result of the experience in 1991, we used foam bottom screens exclusively, beginning in 1992. Some of the foam used in 1992 and 1993 was left over from 1991 and previous years, dried thoroughly and stored in garbage bags at Van Dyke. Serious mortality problems in some tanks in 1992 and 1993 were attributed to the use of "used"

foam bottom screens (Hendricks and Bender 1994). New foam was purchased each year from 1994 through 2001 and no further problems were noted until 2002.

In 2002, problems with foam bottom screens surfaced again (Hendricks 2003). Overall survival of larvae for 2002 was 19% compared to a range of 41% to 94% for the period 1984 through 2001. The low survival was believed to be due to toxicity associated with fire retardants in the foam bottom screen used on Van Dyke incubation jars.

Survival of individual tanks in 2002 followed two patterns (Figure 1). Four tanks, whose eggs were incubated in May-Sloan Jars, exhibited 13-day survival averaging 89.5%. This is typical of survival patterns experienced in the past. All remaining tanks suffered high mortality beginning on days 3 and 4. These tanks experienced problems with larvae lying on the bottom of the tank and the larvae fed very poorly, if at all. All larvae in this group came from eggs incubated in Van Dyke jars, with foam bottom screens. Fourteen-day survival for these tanks averaged 15%, with 15 tanks discarded due to complete mortality.

Hudson River shipment 50 provided definitive proof that the mortalities were related to incubation in Van Dyke jars (Hendricks 2003). The shipment was divided between one Van Dyke jar and four May-Sloan jars. Tank D22 received eggs from the Van Dyke jar and had only 2,000 larvae (1%) survive to 18 days. Tank D32 received eggs from the May-Sloan jars and had 198,000 larvae (83%) survive to 18 days.

May-Sloan jars are the standard for incubation of American shad eggs, however, use of May-Sloan jars in a production facility leads to inefficiencies and other logistical problems due to the small capacity of the May-Sloan jar. In order to maximize egg incubation and larval production, and minimize the effort needed to do that, it is imperative that we utilize egg jars with greater capacity than the standard May-Sloan jar.

In 2003, we evaluated four egg jar configurations, using eggs incubated in May-Sloan jars as a control (Hendricks 2004). Test jars included: Van Dyke jars with open-cell foam bottom screens (special ordered without additives), modified Van Dyke jars with a perforated aluminum plate bottom screen and a "Chapman diffuser", triple May-Sloan jars, and five-foot tall, six-inch diameter Acrylic jars.

In a controlled experiment with 4 replicates (Hendricks 2004), there were no significant differences in mean egg viability for the MS, VD-foam, VD modified and MSXXX jars (72.4%, 70.7%, 68.4% and 61.1% viability respectively). Acrylic jars were eliminated from the test after 2 replicates due to the difficulty in handling them.

In addition, there was no consistent viability advantage between MS and VD-foam jars for production lots of eggs. VD-foam jars exhibited consistently higher viability than MSXXX jars, but this was believed to be an artifact of the enumeration process as it relates to layering of the eggs and the ability to siphon off dead eggs.

Close examination of larval survival from production tanks suggested that incubation of eggs on foam screens appeared to result in lower survival for most tanks (Figure 2). This reduction in survival was not apparent until after 10 days of age. Mean 10d survival for tanks with foam was 95.0%, compared to 97.0% for tanks with no foam. Survival after 10 days appeared to decrease for tanks with foam bottom screens (Figure 3). Tanks with only foam bottom screens (15 tanks) exhibited 19d survival of 79.2% compared to 90.5% for tanks with no foam bottom screens (13 tanks). The experiment reported herein was designed to test that observation by evaluating post-10-day survival of American shad larvae from eggs incubated with foam bottom screens vs. aluminum bottom screens.

Materials and Methods

Hudson River egg shipments were split and incubated in two MSXXX and one Van Dyke-foam jar with the number of eggs in the VD jar equal to the combined number in the two MSXXX jars. Egg enumerations and siphoning of dead eggs followed standard

practice. Larvae from the two MSXX jars were hatched into one tank and larvae from the VD-foam jar was hatched into another tank. Tank mortality was estimated daily by standard methods and the larvae were reared to at least 20 days of age. No statistical testing was done, since the experiment was replicated only twice.

Results and Discussion

Populations of American shad returning to the Hudson River were apparently depressed in 2004, resulting in comparatively small shipments of Hudson River eggs. As a result, only three replicates were attempted. In addition, one tank in the third replicate (Egg shipment 14) suffered nearly complete mortality when a piece of fiberglass insulation lodged in the valve orifice and shut off flow to the tank. Thus, only two replicates were completed.

Egg viability (percent live eggs) for shipments 10 and 14 ranged from 72 to 80%, typical for Hudson River egg shipments (Table 2). Egg shipment 9 exhibited lower viability; 53% for the Aluminum screen and 59% for the foam screens.

Survival of larvae was almost identical between the two types of screens for shipment 9, while the aluminum screen out-performed the foam screen for shipment 10 (Table 2, Figure 4). Forty-two day survival of larvae for shipment 9 was 22.6% for the aluminum screen and 22.9% for the foam screen. Twenty-day survival for shipment 10 was 66.5% for the aluminum screen and 57.8% for the foam screen. A 10% difference in survival, favoring the aluminum screens, was also noted in the 2003 data. Further testing will be required to determine if these differences are statistically significant.

MSXXX jars with aluminum screens were used extensively in 2004 with no major disadvantages noted. A minor problem was noted with shipment 36, a very poor tank-spawn shipment containing 350,000 eggs with only 45,000 live (13%). Most of these 45,000 larvae hatched, but were lost when they could not exit the jar through the deep vertical column of dead eggs. This problem was not observed in other poor tank-spawn shipments. The MSXXX jars are advantageous in that they have a large capacity, yet can

be moved by a single person. The tall size also promotes layering and makes it easier to siphon off dead. I recommend that we construct additional MSXXX jars to replace 13 VD jars on the egg battery. This will result in incubation capacity for 13 VD jars, 57 MSXXX jars and 12 MS jars.

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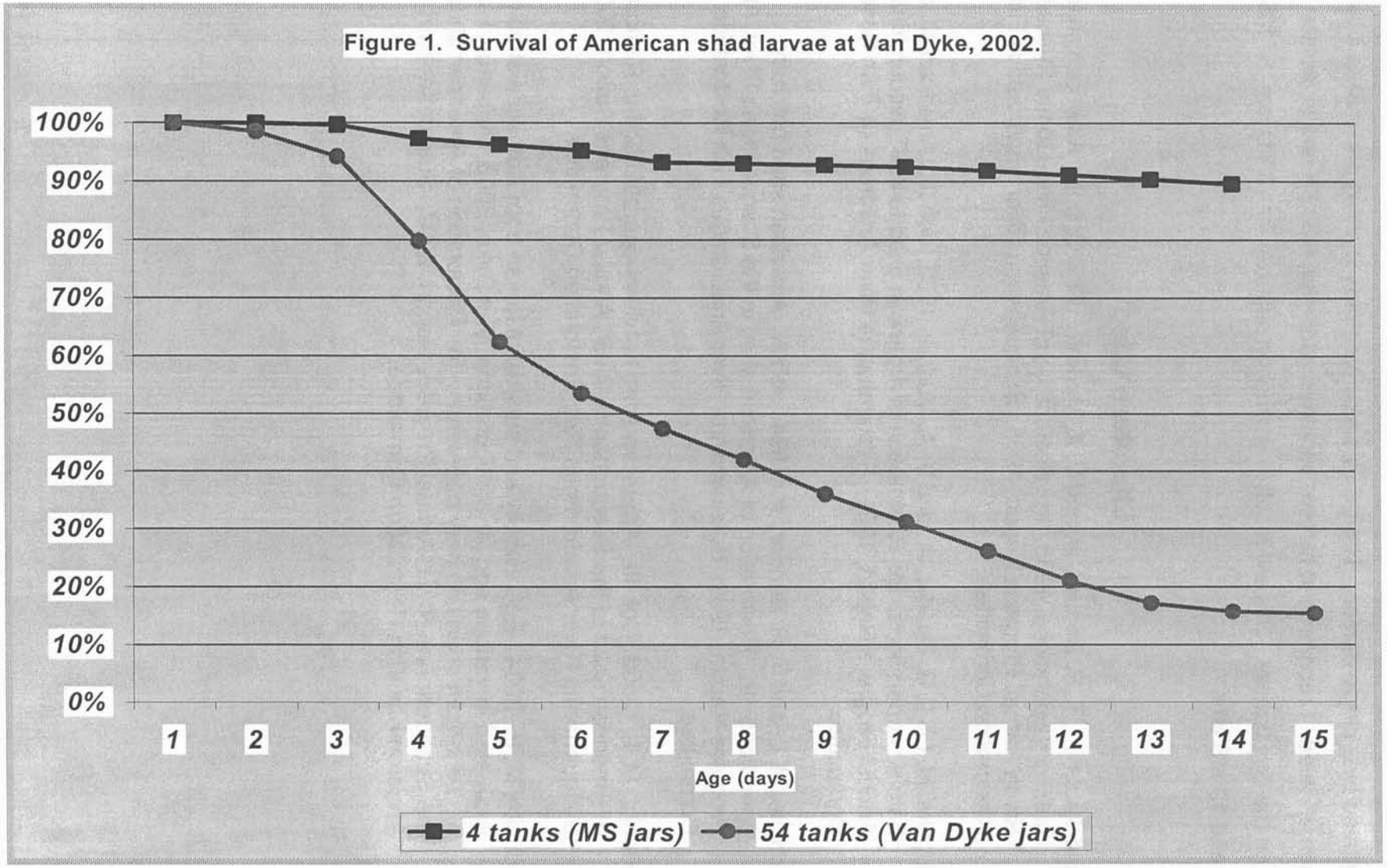
Figure 1. Survival of American shad larvae at Van Dyke, 2002.
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Age (days)
4 tanks (MS jars)
54 tanks (Van Dyke jars)

Figure 2 . Survival of larvae incubated in egg jars with foam vs no-foam, 2003.

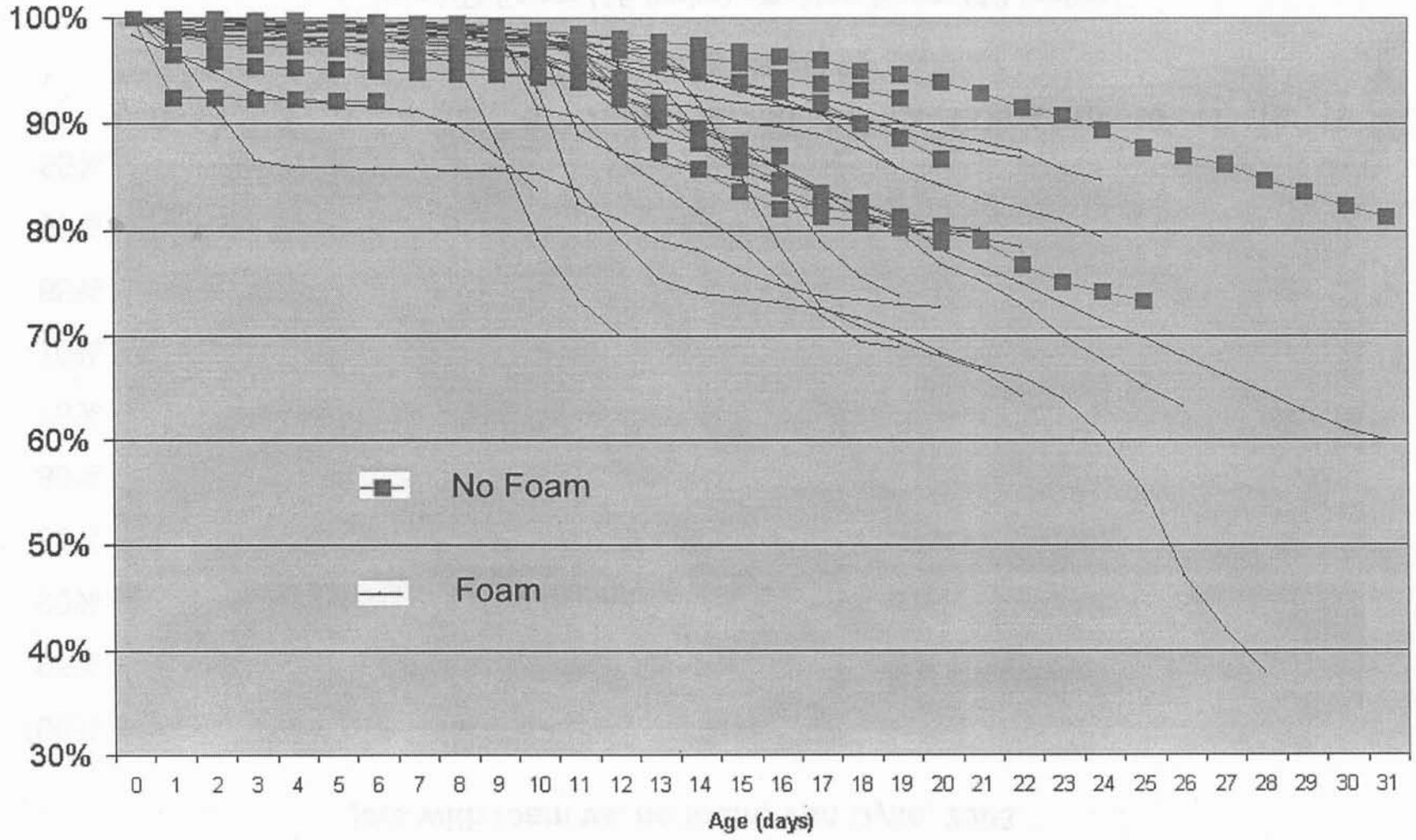

Figure 3. Mean survival for American shad larvae incubated in egg jars with foam vs. no foam, Van Dyke, 2003.

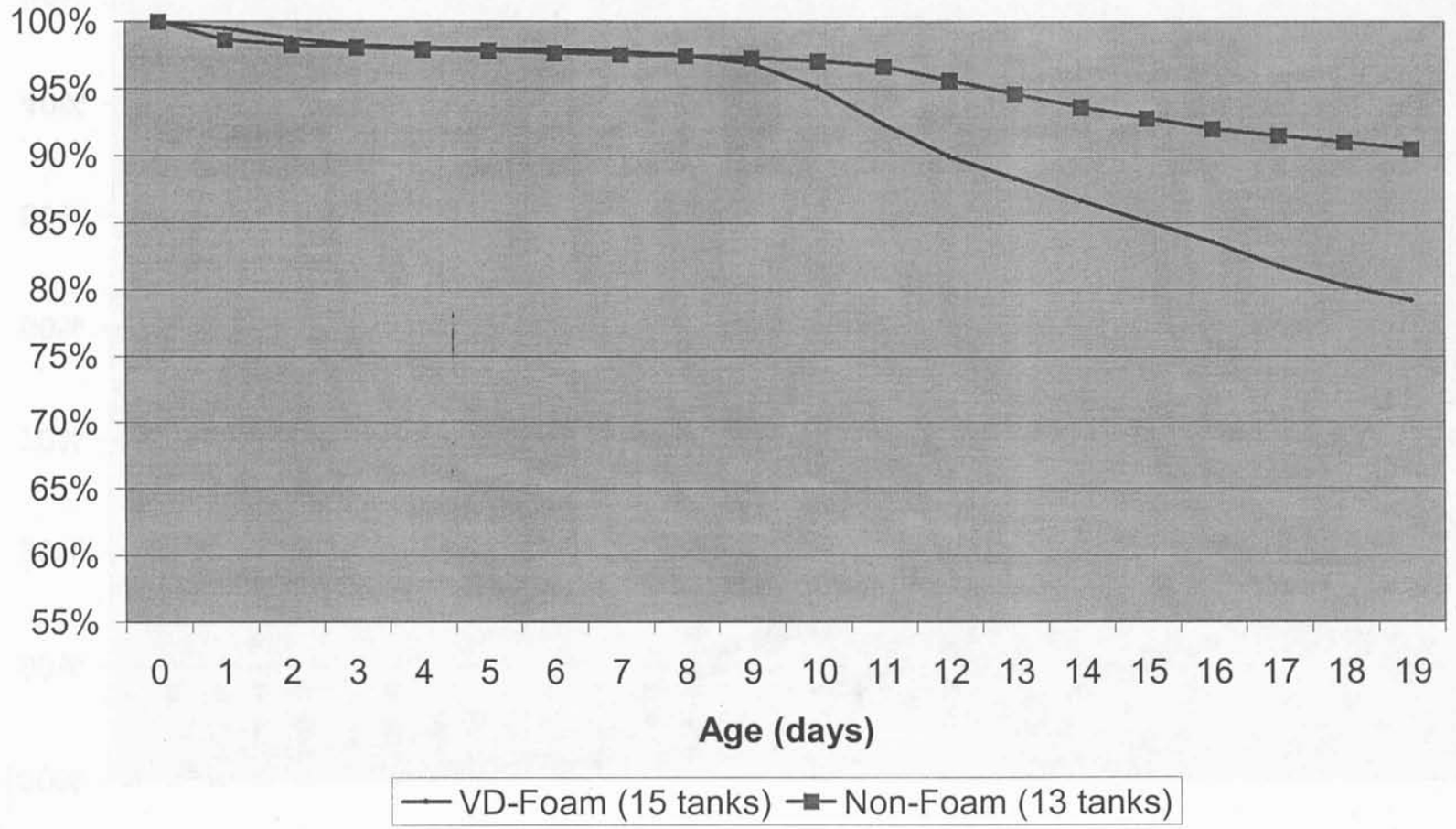

Figure 4. Survival of American shad larvae reared from eggs incubated in jars with aluminum or foam bottom screens, Van Dyke, 2004.

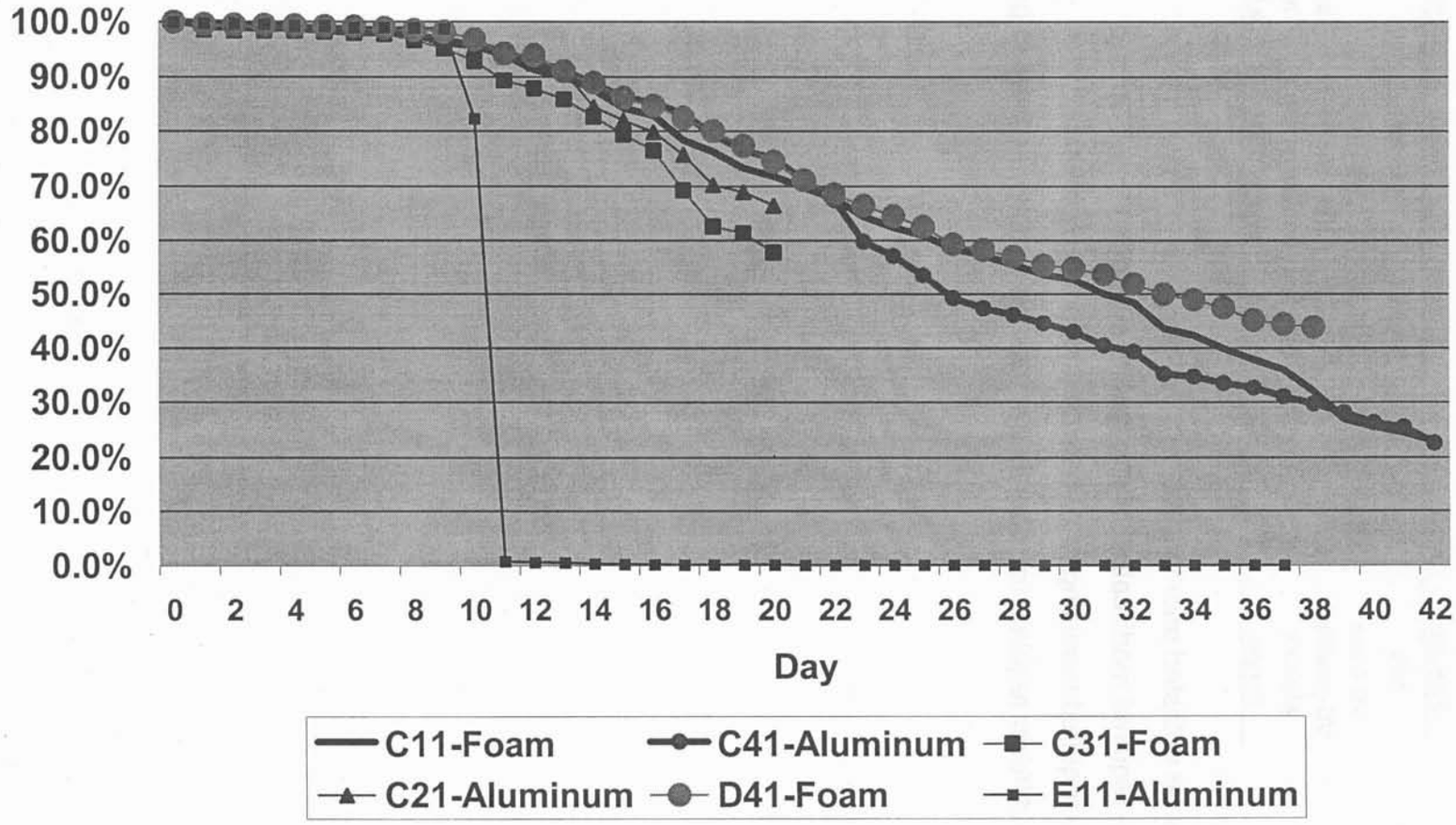

Table 1. Egg jar specifications, Van Dyke, 2003.

Egg Jar	Width	Height	Capacity (Liters)	Bottom Screen	Notes
MS	6"	17"	2.5	window	
VD-foam	13.5"	17"	12.5	foam	
VD-modified	13.5"	17"	12.5	Perf. aluminum	a, d
MSXXX	6"	42"	6.5	window or perf Al.	a,b
Acrylic	6"	60"	8.5	window or perf Al.	a,b,c

a- jar untested prior to 2003

b- required modification of egg battery supports

c- required mounting of jar outside tank during hatching.

d- diffuser required to spray flow across top of bottom screen to prevent dead spots

Table 2. Viability of Hudson River American shad eggs and survival of larvae incubated in egg jars with aluminum or foam bottom screens, Van Dyke, 2004.

Shipment No.	Jar No.	Jar Type	Bottom Screen	Initial Dry Vol (L)	Number of eggs	Percent Live Eggs	Tank	Initial Density	Final Density	Percent Survival	Age at stocking (d)
9	112, 113	MSXXX	Aluminum	13.6	443,216	53.3%	C41	235,995	53,261	22.6%	42
9	301	VD	Foam	13.6	443,216	59.3%	C11	262,747	60,273	22.9%	42
10	114, 115	MSXXX	Aluminum	12.0	362,168	76.0%	C21	275,391	183,000	66.5%	20
10	302	VD	Foam	12.0	362,168	72.3%	C31	261,748	151,228	57.8%	20
14	117, 118	MSXXX	Aluminum	12.0	403,916	74.8%	E11	301,886	200*	0.1%	38
14	305	VD	Foam	12.0	403,916	80.2%	D41	324,119	142,155	43.9%	38

*Piece of fiberglass insulation lodged in valve orifice, shutting off flow and resulting in nearly complete mortality.

JOB IV
ABUNDANCE AND DISTRIBUTION OF JUVENILE AMERICAN SHAD IN THE SUSQUEHANNA RIVER, 2004

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INTRODUCTION

This report summarizes the results of bio-monitoring activities for adult and juvenile alosines conducted in the Susquehanna River and its tributaries in 2004. The Conowingo West Fish Lift continued to be used as a source of adult American shad and river herring to support monitoring activities and tank spawning. Some 3,426 adult shad were collected at the Conowingo West Lift. The majority of these were released back into the Conowingo tailrace. Some 1,055 were retained for tank spawning. Unlike previous years, no alosines were transported and released upstream.
Since the completion of fish passage facilities at Holtwood and Safe Harbor in 1997, the Conowingo East Lift has operated in fish passage mode. American shad had access to the Fabri-Dam on the Susquehanna main stem, and Warrior Ridge or Raystown Dams on the Juniata. Portions of large tributaries including Muddy Creek, West Conewago Creek, Conestoga River, Conodoguinet Creek, and Swatara Creek were also accessible to American shad.

During the 2004 spring migration, Conowingo East Lift passed 109,360 American shad while fishways at Holtwood, Safe Harbor, and York Haven passed 3,428, 2,109 and 219 American shad, respectively. Only 190 river herring were passed at Conowingo Dam. Two herring were passed at Holtwood, however, these were small fish, probably not anadromous migrants.

Juvenile American shad in the Susquehanna River above Conowingo Dam are derived from two sources - natural reproduction of adults passed at the lower river hydroelectric projects, and hatchery produced, marked larvae from Pennsylvania Fish and Boat Commission's (PFBC) Van Dyke Hatchery in Pennsylvania. Juveniles occurring in the river below Conowingo and the upper Chesapeake Bay may result from natural spawning below or above dams and hatchery fry stockings either in Maryland or from upstream releases in Pennsylvania.

During the 2004 production season, the PFBC Van Dyke Research Station for Anadromous Fish released 4.7 million shad larvae in the Susquehanna Basin, Pennsylvania. Larvae were released coinciding with receding flows (Figure 1) between 17 May and 22 June in the following locations and numbers:

Juniata River (various sites)	2,600,678
Susquehanna River (near Montgomery Ferry)	283,226
Conodoguinet Creek	200
Conestoga River	60,273
Swatara Creek	53,261
West Conewago Creek	142,155
North Branch Susquehanna River (PA)	479,805
West Branch Susquehanna River	282,143
North Branch Susquehanna River (NY)	484,933
Chemung River (NY)	343,253

METHODS

Sampling for juvenile American shad was conducted at locations in the Susquehanna River Basin during the summer and fall in an effort to document in-stream movement, out-migration, abundance, growth, and stock composition/mark analysis. Recoveries from all sources were provided to the PFBC for otolith analysis. Otoliths were analyzed for tetracycline marks to determine hatchery versus wild composition of the samples.

Haul Seining - Main Stem

Haul seining in the lower Susquehanna River was scheduled once each week beginning mid-July and continuing through October. Fifteen weekly sampling events were planned for 2004, however, high river flow in late July through early August, again in mid-August, and through much of September necessitated postponement of sampling during these periods. Attempts to re-schedule the missed events later in the year were thwarted by additional high river flow events. A total of 11 sampling events occurred. Sampling was concentrated near the Columbia Borough boat launch since this location proved very productive in past years. Sampling consisted of 6 hauls per date beginning at sunset and continuing into the evening with a net measuring 400 ft x 6 ft with 3/8 in stretch mesh.

Holtwood Dam, Peach Bottom APS, and Conowingo Dam

Sampling at the Holtwood Dam inner fore-bay began on 14 September and continued every third day through 1 December 2004. A total of 30 sampling events were planned for 2004. Once initiated, high river flow in late September necessitated postponement of three sampling events. By early December, it was apparent that a continuation of the program would not result in any improvement in the catch. Therefore, the program was cancelled after completion of 24 of the 30 scheduled events.

Sampling at the Holtwood Dam inner fore-bay was conducted using a fixed 8-ft square lift-net. Sampling began at sunset and consisted of 10 lifts with a 10-minute interval between lift cycles. The lift-net was placed on the north side of the coffer cell in the inner fore-bay. A lighting system was used to illuminate the water directly over the lift-net similar to that employed in previous years.

Intake screens were sampled for impinged alosines at Peach Bottom Atomic Power Station three times per week from 6 October to 3 December for a total of 23 samples. Conowingo Hydroelectric Station's cooling water intake screens were sampled for alosines twice weekly from 3 October to 8 December for a total of 16 samples.

Susquehanna River Mouth and Flats

Maryland DNR sampled the upper Chesapeake Bay using haul seines in the summer and fall.

Disposition of Samples

Sub-samples of up to 30 juveniles per day were used for otolith analysis. Samples of shad from most collections were returned to PFBC's Benner Spring Fish Research Station for analysis of tetracycline marks on otoliths. Otoliths were surgically removed from the fish, cleaned and mounted on slides, ground to the focus on the sagittal plane on both sides, and viewed under ultraviolet light to detect fluorescent rings indicating tetracycline immersion treatments.

RESULTS

Haul Seining - Main Stem

A total of 25 juvenile American shad were captured by haul seine resulting in a Geometric Mean Catch-Per-Unit-Effort (GM CPUE, individual haul) of 0.17 (Tables 1 and 2). Juvenile American shad were captured on August 31 (16), September 7 (5) and September 9 (4). All shad captured were of hatchery origin. Table 3 lists weekly catches of American shad by haul seine from 1989 to 2004. Catches generally peaked in August and September except in 1989 and 1992 when catches peaked in July.

Holtwood Dam, Peach Bottom APS, and Conowingo Dam

Lift-netting at Holtwood Dam inner fore-bay resulted in no juvenile American shad captured in 240 lifts (Table 4). Catch per unit effort was 0.00 (Table 5). Historical weekly catches peaked in October, except in 1985, 1997, 2000, and 2001 when catches peaked in November (Table 5). One alewife was captured by lift-net on 14 September, 2004. Peach Bottom intake screens produced no juvenile American shad or blueback herring, and 6 alewives (Table 7). Cooling water strainers at Conowingo produced no juvenile American shad or blueback herring, and 1 alewife (Table 8).

Susquehanna River Mouth and Flats

In 2004, 151 juvenile American shad were captured at seven permanent sites by Maryland DNR's juvenile finfish haul seine survey during 42 hauls, and 53 juvenile American shad were captured at the auxiliary sites in 15 hauls (Table 9). These fish have been sent to a federal facility for OTC and otolith microstructure analysis but results are not yet available. Juvenile American shad indices for the upper Bay have increased exponentially since 1980 (Figure 5; $r^2 = 0.32$ $P<0.001$).

Otolith Mark Analysis

Results of otolith analysis are presented in Table 10. A total of 25 juvenile American shad were collected in haul seine collections. All 25 were analyzed for hatchery marks and all 25 were of hatchery origin. Twenty-two (88%) were larvae from Hudson River eggs stocked in the Juniata or middle Susquehanna River. The remaining three (12%) were larvae from Susquehanna eggs stocked in the Juniata or middle Susquehanna River.

DISCUSSION

Spring river conditions for the Susquehanna River basin during 2004 could be characterized by relatively high and variable flows in May and June (Figures 1 and 3). Water temperatures at Conowingo Dam were generally between 60 and 65°F during late April and early May, then increased rapidly from 62.3 on May 9 to 75.6 on May 19 (Figure 2). Temperatures then remained above 70°F for the remainder of the spawning season. This rapid and sustained rise in water temperature had the effect of shortening the length of the spawning season and contributed to a reduction in eggs delivered to the hatchery.

Variable flows in the watershed during stocking season may have contributed to poor survival of larvae, since many of the stocking events were followed by increases in flow resulting in conditions that are not optimal for larval survival (Figure 1).

River flow was consistently high for the entire season due to abundant rainfall. Flows in 2004 dropped below the 72-year mean for short periods, but the polynomial trend line for 2004 flow was consistently above the mean except for a short period during April (Figure 3). In interpreting Figure 3, it should be noted that mean flows are skewed from "normal" due to the influence of very high, flood waters on the mean. A better measure of "normal" flows would be median, however, median flows are not readily available from USGS.

Fish passage at Holtwood and York Haven was severely impaired by persistent high river flows and constant spilling which adversely affected attraction at the fishway entrances.

Abundance – Main Stem

Comparison of relative abundance of juvenile alosines in the Susquehanna River from year to year is difficult due to the opportunistic nature of sampling and wide variation in river conditions, which may influence catches. Based on river haul seine and lift-net catch rates, abundance of juvenile American shad in 2004 was among the lowest recorded in recent history.

GM CPUE for haul seine (both individual lifts, and combined daily lifts, Table 2) was the second lowest value ever recorded for that gear type since 1990. Lift net collections in the Holtwood Dam forebay have been ongoing since 1985. In 240 lifts, over an 11-week period, no juvenile shad were collected by lift net in 2004, a first in the history of the program (Table 5). Low juvenile shad abundance in 2004 is most likely attributed to a combination of limited natural reproduction resulting from poor fish passage performance and poor recaptures of hatchery fish. High river flows appeared to have a negative impact on capture of stocked hatchery larvae. This may be due to a direct negative impact on survival of hatchery larvae or early out-migration resulting from high flow events in late July and September, 2004.

Low abundance of juvenile shad has been observed for 3 years in a row (Tables 2 and 5). Poor hatchery performance was responsible for decreased abundance of hatchery reared juvenile shad in 2002. High river flows were responsible for decreased abundance of hatchery reared shad in 2003 and 2004. High river flows also negatively impacted adult fish passage in 2002 to 2004, resulting in low abundance of wild juvenile shad. Poor juvenile production in 2002 to 2004 will likely impact adult returns in 2006 to 2010.

Stock Composition and Mark Analysis

All otoliths analyzed from haul seine collections at Columbia were hatchery fish (Table 10). In 2003, 24 juvenile shad were captured at Columbia, including 2 wild and 22 hatchery fish.

SUMMARY

- Juvenile American shad were successfully collected only by haul seine.
- Haul seine GM CPUE (combined daily lifts) of 0.22 was the second lowest recorded for that gear type since 1985.
- Lift-netting GM CPUE (combined daily lifts) of 0.00 was the lowest recorded for that gear type since 1985.
- All otoliths analyzed were hatchery in origin.
- Juvenile production in the Susquehanna River basin was poor and was influenced by decreased numbers of adult fish passed by fish passage facilities and poor catches of hatchery fish resulting from persistent high river flows.

ACKNOWLEDGMENTS

RMC/Normandeau Associates (Drumore, PA) was contracted by the PFBC to perform juvenile collections. Many individuals supplied information for this report. Ken Woomer and Coja Yamashita processed shad otoliths.

Figure 1. Number of larvae stocked and river flow for American shad larvae stocked in the Juniata River, 2004.

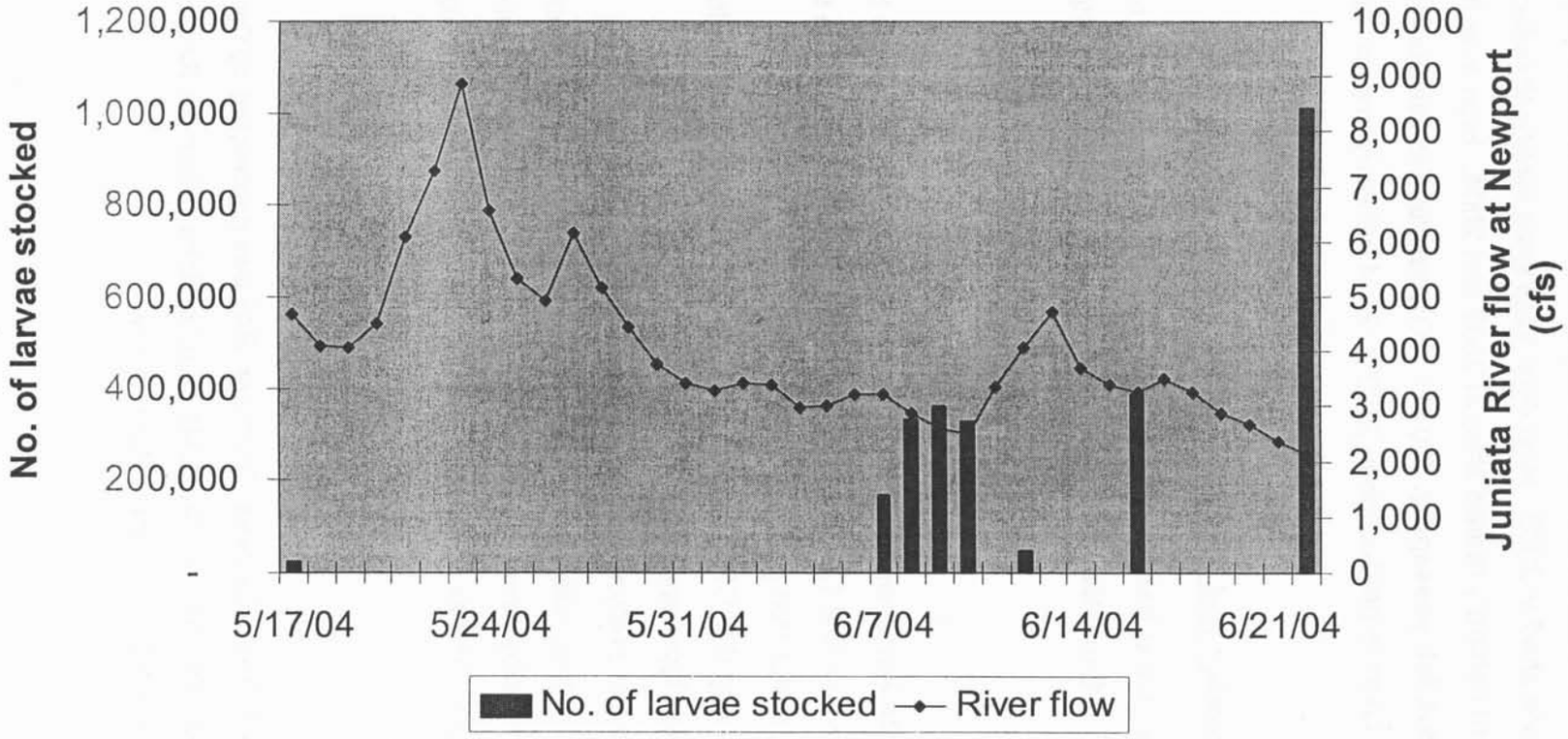

Figure 2. Water Temperature at the Conowingo Dam East Fish Lift

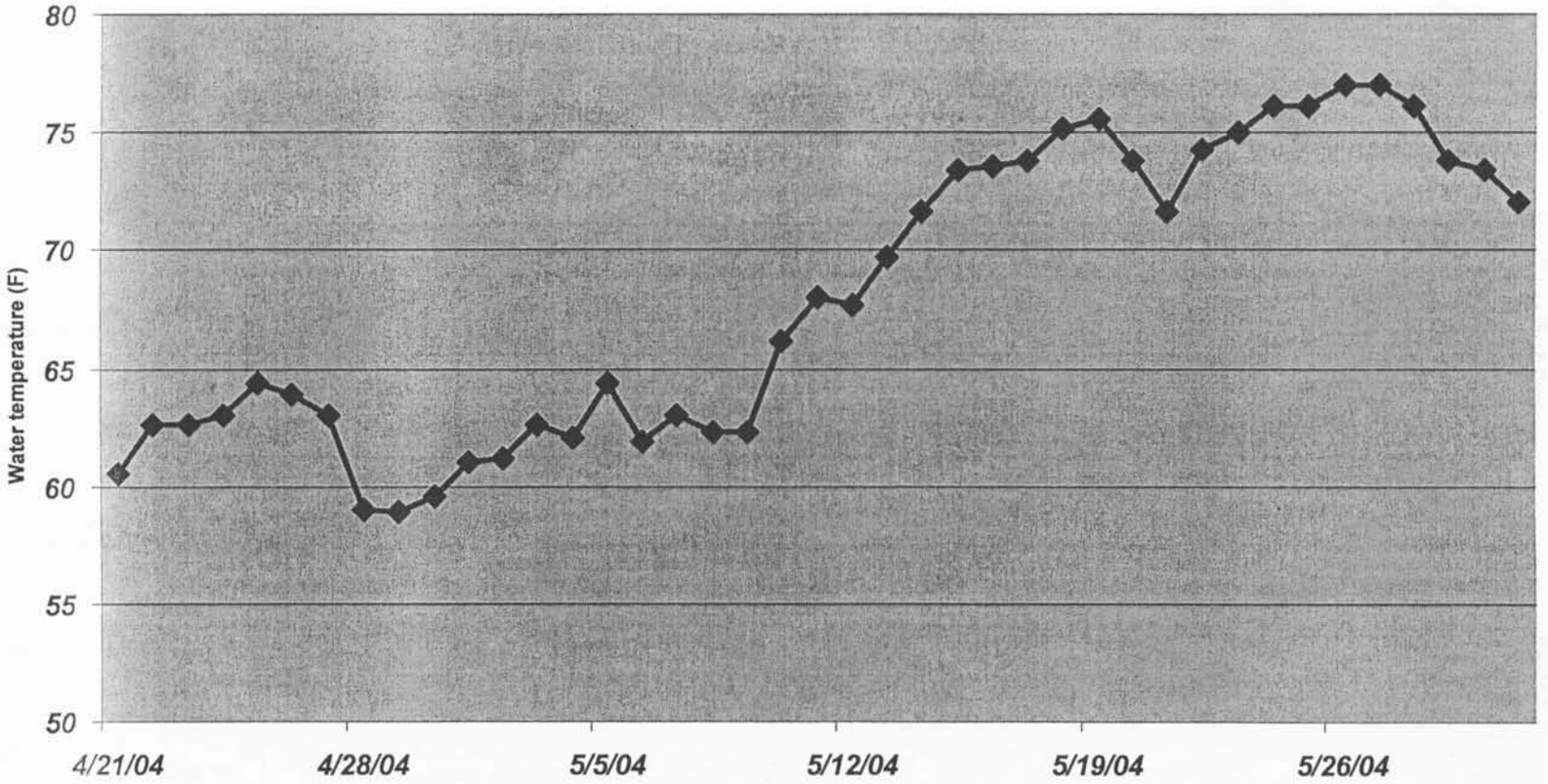

Figure 3. Susquehanna River flow at Marietta, 2004 and 72-year mean.

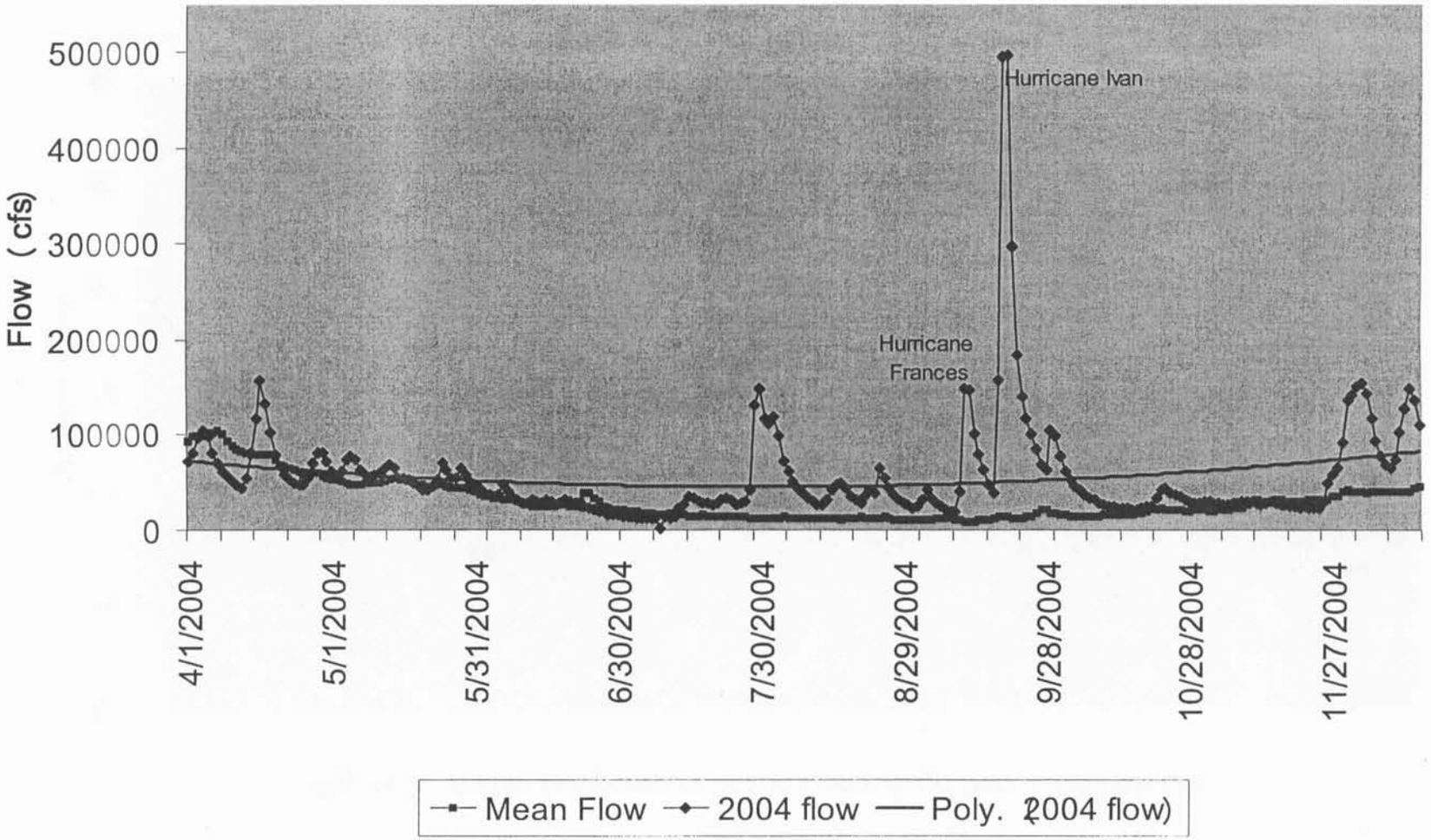

Figure 4. Number of American shad collected by haul seine and river flow, Susquehanna River, 2004.

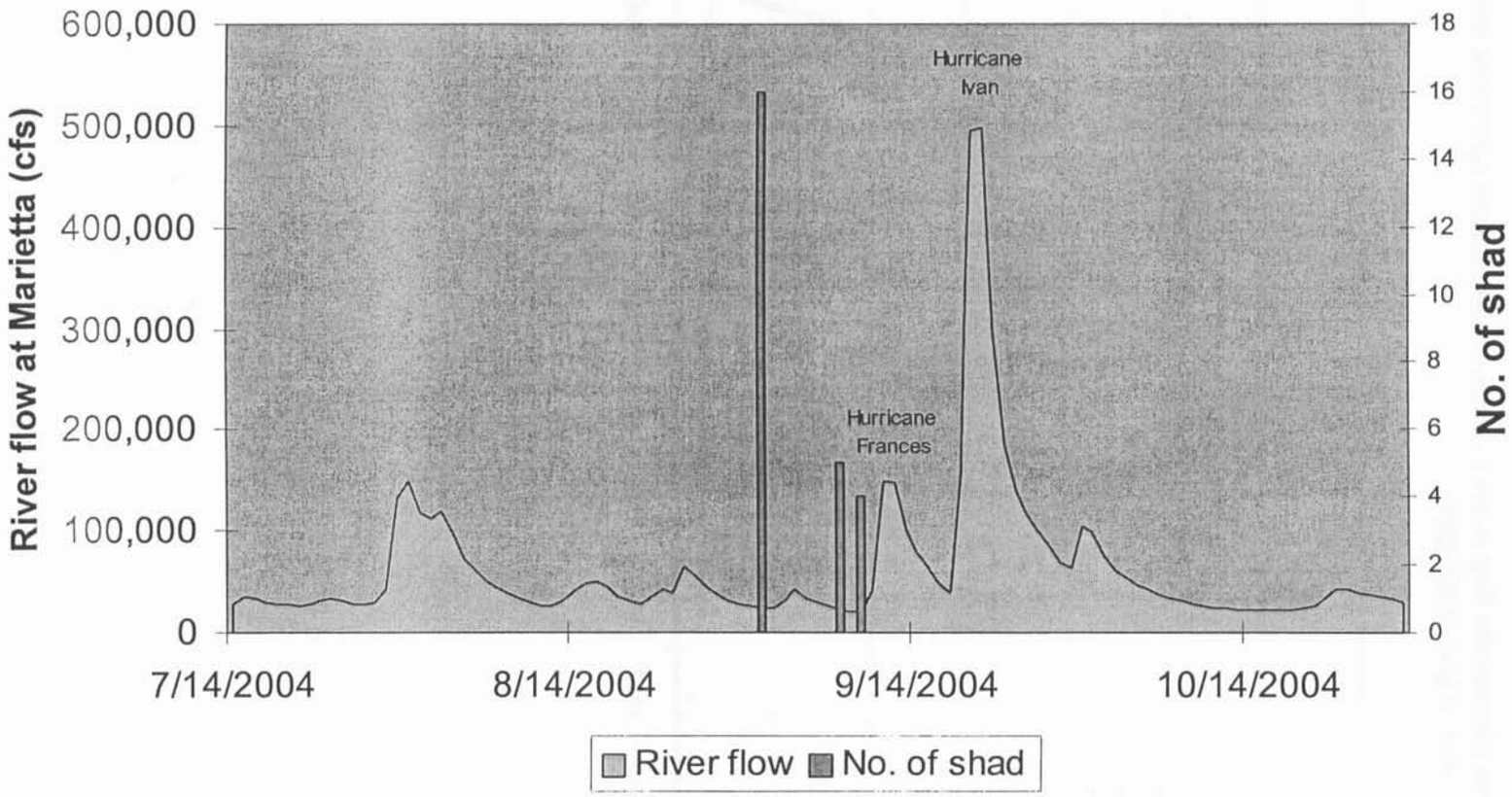

Figure 5. Upper Chesapeake Bay juvenile American shad indices (geometric mean) with exponential line, 1980-2004.

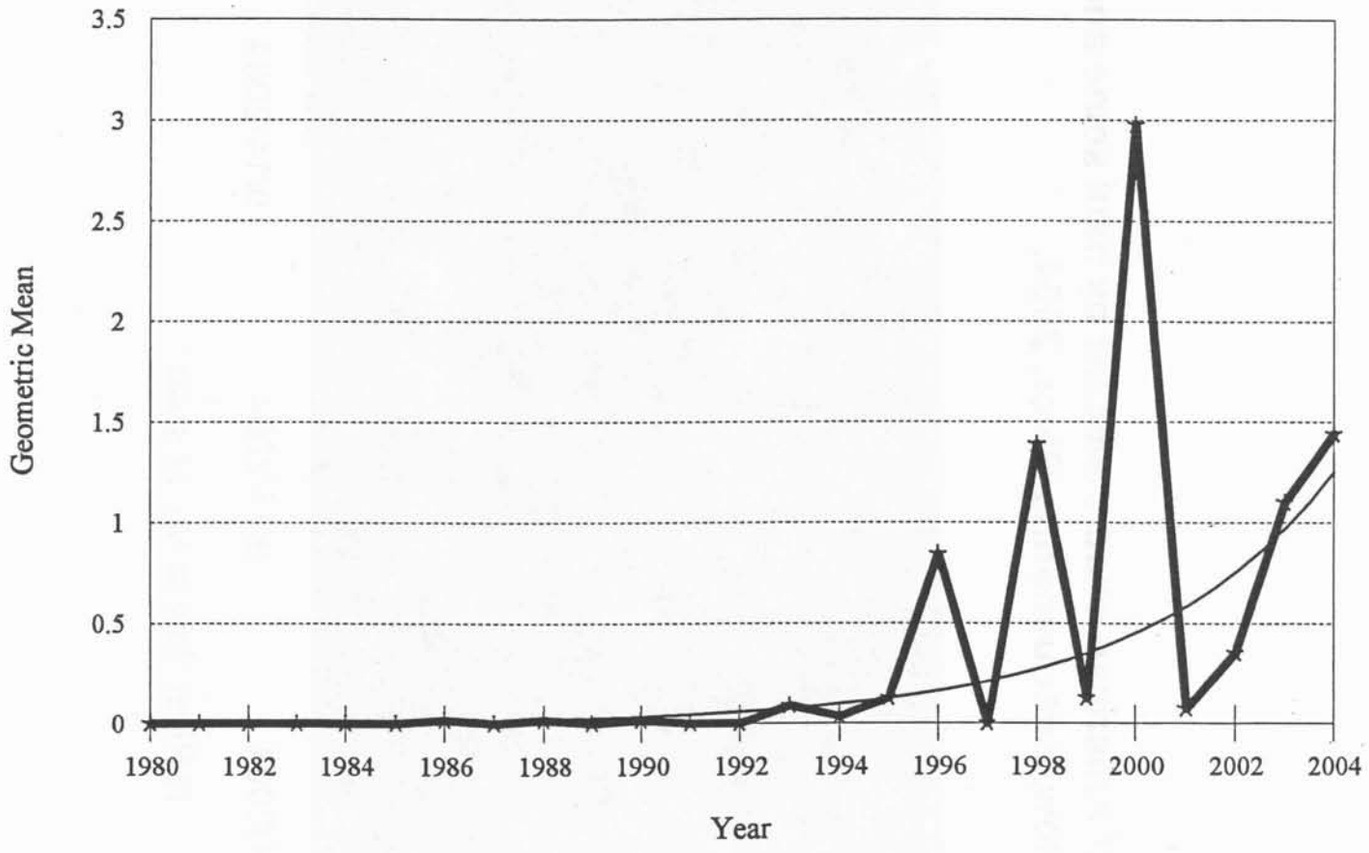

Table 1. Number of fish collected by haul seine from the lower Susquehanna River near Columbia, Pennsylvania, 2004.

Date	14-Jul	21-Jul	10-Aug	31-Aug	2-Sep	7-Sep	9-Sep	7-Oct	12-Oct	20-Oct	28-Oct	Total
Daily Mean River Flow (cfs)	27,600	30,500	28,650	23,200	39,450	21,200	20,425	33,600	23,800	26,500	29,600	
Water Temperature (°C)	23.8	27.0	24.2	25.2	25.5	23.0	23.0	16.5	15.0	11.5	12.0	
Secchi Disk (in)	6	22	20	32	30	24	20	40	55	80	60	
American shad				16		5	4					25
Gizzard shad	57	8	24	1	5	3	2		3			103
Golden shiner	2											2
Comely shiner									39	12	18	69
Spottail shiner	3	3		2	1	2	8			32		51
Spotfin shiner	40	20	9		3	1		1	7		15	96
Mimic shiner		1						11				12
Bluntnose minnow						1		1				2
Fallfish	2	4										6
Quillback						1						1
White sucker		2		11	2							15
Channel catfish		1	1	4		1						7
Smallmouth bass		3		1								4
Tessellated darter	1			1								2
Walleye						1						1
Total	**105**	**42**	**34**	**36**	**11**	**15**	**14**	**13**	**49**	**44**	**33**	**396**
No. of Species	**6**	**8**	**3**	**7**	**4**	**8**	**3**	**3**	**3**	**2**	**2**	**15**

Table 2. Index of abundance for juvenile American shad collected by haul seine at Marietta, Columbia and Wrightsville, 1990-2004.

Year	No. Hauls	No. Fish	Mean Combined Daily CPUE	GM Combined Daily CPUE	GM Individual Haul CPUE*	No. Wild Fish	Mean Combined Daily CPUE (Wild)	GM Combined Daily CPUE (Wild)
1990	87	285	4.40	1.23		0	0.15	0.11
1991	144	170	1.01	0.54		80	0.48	0.35
1992	92	269	4.24	1.45		146	2.49	0.78
1993	111	218	1.90	1.22		174	1.61	1.01
1994	110	390	4.74	2.29		254	3.19	1.38
1995	48	409	8.92	7.89		58	1.29	1.06
1996	105	283	2.89	2.05		157	1.61	1.20
1997	90	879	9.77	6.77	3.36	136	1.51	1.24
1998	94	230	2.51	1.03	0.50	5	0.05	0.05
1999	90	322	3.58	1.16	0.67	13	0.15	0.13
2000	90	31	0.34	0.26	0.14	0	0.00	0.00
2001	90	377	4.19	3.04	1.52	119	1.32	1.25
2002	84	0	0.00	0.00	0.00	0	0.00	0.00
2003	48	17	0.35	0.28	0.20	2	0.04	0.04
2004	66	25	0.38	0.25	0.17	0	0.00	0.00

* Required by ASMFC

Table 3. **Weekly catch of juvenile American shad by haul seine from the lower Susquehanna River, 1989-2004.**

Week	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
I Jul				0		2											**2**
II Jul	1,048		0	120	0	27		2	44	10	0	7					**1,258**
III Jul			0	6		70	53	18	28	14	0	3	46	0	0	0	**238**
IV Jul	45	31			0	60	24	15	22	144	1	0	23	0	0	0	**365**
I Aug		0	0	20	0	24	29	32	14	30	1	2	19	0	*	*	**171**
II Aug	61	0	0	2	8	13	35	56	20	0	0	6	70	0	*	*	**271**
III Aug	7	69	0	16	0	46	40	43	171	9	0	1	37	0	*	0	**439**
IV Aug					13		42	39	120	10	8	0	36	0	0	*	**268**
I Sep		25	12		20		43	34	129	3	2	0	36	0	8	16	**312**
II Sep		4			15	50	31	3	46	3	*	0	23	0	5	0	**180**
III Sep		93	16		26	25	34	1	89	3	264	0	31	0	4	9	**586**
IV Sep		28	30		27	14	46	12	59	1	17	0	15	0	0	*	**249**
V Sep		0	73		11	5	15	15	32	0	20	1	34	0	*	*	**206**
I Oct		0	69	2	22	5	19	10	91	3	1	0	6	0	*	*	**228**
II Oct		0	7		0	2	31	3	0	0	3	11	1	0	*	0	**58**
III Oct			5			10			14	0	5	0	0	*	0	0	**34**
IV Oct			0	0			0	0					0	0	*	0	**0**
TOTAL	**1,161**	**250**	**212**	**166**	**142**	**353**	**442**	**283**	**879**	**230**	**322**	**31**	**377**	**0**	**17**	**25**	**4,865**

* No sampling due to high river flow.

Table 4. Number of fishes collected by an 8 x 8 ft lift net from Holtwood Power Station inner forebay, 14 September through 1 December, 2004.

Date:	14 Sep	17 Sep	29 Sep	02 Oct	05 Oct	08 Oct	11 Oct	14 Oct	17 Oct	20 Oct	23 Oct	26 Oct	29 Oct
Water Temp (°C):	20.2	20.5	19.0	18.0	17.0	17.0	16.5	15.0	13.5	13.0	11.5	12.0	12.0
Secchi (in):	10	16	10	21	30	32	27	33	40	43	70	55	57
River Flow (cfs):	74,900	36,700	106,000	58,450	40,500	30,650	24,600	23,500	22,000	26,500	43,000	34,900	27,500
Start Time (hr):	1850	1830	1840	1818	1807	1810	1803	1815	1800	1802	1750	1756	1722
End Time (hr):	2001	1958	1955	1937	1940	1933	1912	1922	1910	1910	1848	1903	1854
Alewife	1	-	-	-	-	-	-	-	-	-	-	-	-
Gizzard shad	-	2	-	-	-	-	-	-	-	-	-	-	-
Comely shiner	-	-	-	-	-	-	-	-	-	-	1	-	2
Spotfin shiner	-	30	-	1	-	-	2	-	-	-	-	-	-
Bluegill	1	-	-	2	-	-	-	-	-	-	-	-	-
Total	**2**	**32**	**0**	**3**	**0**	**0**	**2**	**0**	**0**	**0**	**1**	**0**	**2**
No. of Species	**2**	**2**	**0**	**2**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**1**

Date:	01 Nov	04 Nov	07 Nov	10 Nov	13 Nov	16 Nov	19 Nov	22 Nov	25 Nov	28 Nov	01 Dec	
Water Temp (°C):	13.3	13.0	11.5	10.0	8.0	7.0	8.0	9.5	10.5	8.5	7.5	
Secchi (in):	50	53	61	72	78	90	90	63	60	12	12	
River Flow (cfs):	29,300	26,700	28,675	29,660	28,540	26,900	24,125	23,400	22,800	68,400	141,200	
Start Time (hr):	1654	1642	1630	1624	1622	1627	1650	1623	1622	1635	1615	
End Time (hr):	1755	1742	1729	1742	1740	1740	1800	1720	1733	1737	1730	**TOTAL**
Alewife	-	-	-	-	-	-	-	-	-	-	-	**1**
Gizzard shad	-	-	-	-	-	-	-	-	-	-	-	**2**
Comely shiner	-	-	-	-	-	-	-	-	-	-	-	**3**
Spotfin shiner	-	-	-	-	-	-	-	-	-	-	-	**33**
Bluegill	-	-	-	-	-	-	-	-	-	-	-	**3**
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**42**
No. of Species	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**

Table 5. Index of abundance for American shad collected by lift net in the forebay of Holtwood Hydroelectric Station, 1985-2003.

Year	No. Lifts	No. Fish	Mean Combined Daily CPUE	GM Combined Daily CPUE	GM Individual Lift CPUE*	No. Wild Fish	Mean Combined Daily CPUE (Wild)	GM Combined Daily CPUE (Wild)	Migration Duration (days)
1985	378	3,626	20.31	7.55		**	**		65
1986	404	2,926	10.30	5.71		**	**		64
1987	428	832	3.17	1.90		**	**		72
1988	230	929	3.87	1.28		**	**		51
1989	286	556	0.86	0.43		**	**		35
1990	290	3,988	13.75	3.67		70	0.24	0.18	72
1991	370	208	0.56	0.39		19	0.05	0.05	71
1992	250	39	0.16	0.12		14	0.06	0.05	43
1993	250	1,095	4.38	1.20		669	2.79	0.86	56
1994	250	206	0.82	0.48		35	0.15	0.13	71
1995	115	1,048	9.11	1.26		83	0.72	0.32	34
1997	300	1,372	4.57	0.88	0.61	100	0.33	0.23	46
1998	300	180	0.60	0.37	0.22	9	0.03	0.03	67
1999	300	490	1.63	0.78	0.50	19	0.06	0.07	40
2000	300	406	1.35	0.61	0.18	4	0.01	0.01	43
2001	299	1,245	4.18	1.37	0.43	538	1.81	0.45	73
2002	220	68	0.31	0.15	0.09	15	0.07	0.05	13
2003	300	61	0.20	0.13	0.07	3	0.01	0.01	22
2004	240	0	0.00	0.00	0.00	0	0.00	0.00	0

* Required by ASMFC

** Most of the Holtwood samples processed were from cast net collections.

Table 6. Historical weekly catch per unit effort (CPUE) of juvenile American shad collected by an 8 x 8 ft lift net at Holtwood Power Station inner forebay, August-December 1985-2004*.

	Historical Years																		Year
Week	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
II Aug	-	-	-	-	-	-	0.0	-	-	-	0.0	-	-	-	-	-	-	-	-
III Aug	-	-	-	-	-	0.0	0.0	0.0	-	-	0.0	-	-	-	-	-	-	-	-
IV Aug	-	-	-	-	-	0.0	0.0	0.0	-	-	0.0	-	-	-	-	-	-	-	-
I Sep	-	-	-	0.0	-	0.8	0.0	1.4	0.0	0.5	0.0	-	-	-	-	-	-	-	-
II Sep	-	-	1.3	-	-	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.4	0.0	0.0	-	-	-
III Sep	-	-	0.7	-	2.3	0.0	0.0	0.5	0.0	0.0	-	0.0	0.0	9.7	0.0	0.0	-	-	-
IV Sep	-	-	0.3	-	-	7.5	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.3	0.0	2.6	0.0	0.0	**0.0**
V Sep	-	-	0.9	0.0	1.2	3.9	0.1	0.1	0.2	4.3	0.1	0.0	0.1	4.7	0.0	0.5	0.0	0.0	**
I Oct	-	16.7	4.1	0.1	1.2	2.0	0.1	0.0	0.2	3.5	0.0	0.0	0.8	3.7	0.0	0.1	0.0	0.4	**0.0**
II Oct	0.1	30.3	4.5	0.0	3.2	52.0	0.6	0.2	0.1	0.7	5.0	0.0	1.9	2.1	0.1	0.2	0.0	1.6	**0.0**
III Oct	1.0	5.4	1.3	10.0	0.5	50.2	0.9	0.3	17.5	0.3	68.9	0.2	1.3	1.0	0.7	0.0	1.7	0.5	**0.0**
IV Oct	41.6	5.3	4.8	19.1	0.0	34.3	1.1	0.1	14.8	0.1	56.0	0.0	1.7	0.0	2.5	2.5	1.7	0.3	**0.0**
I Nov	28.6	4.1	4.5	2.0	0.0	1.7	2.4	0.0	19.0	0.6	9.3	25.1	1.6	0.0	0.6	4.7	0.0	0.0	**0.0**
II Nov	10.8	19.5	0.3	0.3	0.0	0.4	0.5	0.7	1.6	0.1	0.0	27.1	0.1	0.0	13.2	4.2	0.0	0.0	**0.0**
III Nov	57.6	6.3	0.7	0.5	-	0.0	0.8	0.0	0.1	0.0	0.0	3.0	0.1	0.0	5.5	0.1	0.0	0.0	**0.0**
IV Nov	15.1	-	-	0.3	-	0.0	1.6	-	0.0	0.0	0.0	0.5	0.0	0.0	1.2	7.0	0.0	0.0	**0.0**
I Dec	62.8	14.2	0.0	0.0	-	-	-	0.9	-	0.0	-	0.0	0.0	0.0	0.0	30.9	0.0	0.0	**0.0**
II Dec	4.3	0.1	-	-	-	-	1.2	-	-	-	-	-	0.6	-	-	-	-	0.0	**0.0**
III Dec	0.5	0.0	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-
Total shad	3,626	2,926	832	929	556	3,988	208	39	1,095	206	2,100	1,372	180	490	406	1,245	68	61	**0**
Total lifts	378	404	428	230	286	290	370	240	240	250	230	300	300	300	290	300	260	300	**240**
CPUE	9.6	7.2	1.9	4.0	1.9	13.8	0.6	0.2	4.6	0.8	9.1	4.6	0.6	1.6	1.4	4.2	0.3	0.2	**0.0**

* The lift net program was not conducted in 1996 due to flood damage to the platform.

** No sampling due to high river flows (>600,000 cfs), which flooded the forebay area.

Table 7. Number of fish collected during intake screen sampling by unit at Peach Bottom Atomic Power Station in fall, 2004.

Species	Unit 2	Unit 3	Total
Alewife	1	5	**6**
Gizzard shad	635	711	**1,346**
Golden shiner	0	1	**1**
Comely shiner	13	33	**46**
Spotfin shiner	2	5	**7**
Spottail shiner	1	0	**1**
Quillback	0	1	**1**
Flathead catfish	1	1	**2**
Channel catfish	11	10	**21**
Rock bass	2	1	**3**
Green sunfish	2	1	**3**
Pumpkinseed	1	1	**2**
Bluegill	35	31	**66**
Smallmouth bass	3	2	**5**
Largemouth bass	4	4	**8**
White crappie	4	9	**13**
Yellow perch	3	29	**32**
TOTAL	***718***	***845***	***1,563***

Table 8. Species and number of fish collected during cooling water intake sampling at Conowingo Dam in fall, 2004.

Species	Francis Units (7)	Kaplan Units (4)	Total
Alewife	0	1	**1**
Gizzard shad	47	184	**231**
Comely shiner	2	1	**3**
Spotfin shiner	1	0	**1**
Channel catfish	1	4	**5**
Bluegill	0	1	**1**
Walleye	1	0	1
TOTAL	*52*	*191*	*243*

Table 9. Catch of juvenile American shad by location from the upper Chesapeake Bay during the 2004 Maryland DNR Juvenile Finfish Haul Seine Survey.

Permanent Sites

Location	Round 1	Round 2	Round 3	Totals
Howell Point	12	21	6	39
Tims Creek	2	0	0	2
Ordinary Point	4	0	0	4
Parlor Point	1	0	0	1
Elk Neck State Park	5	1	0	6
Welch Point	39	29	0	68
Hyland Point	13	18	0	31
Total	76	69	6	**151**
Mean Catch Per Haul	**5.43**	**4.93**	**0.43**	

Auxiliary Sites

Location	Round 1	Round 2	Round 3	Totals
Carpenter Point	1	2	0	3
Popular Point	N/A	N/A	N/A	N/A
Plum Point	6	21	2	29
Spoil Island	0	1	3	4
Tydings Estate	13	3	1	17
Tolchester	0	0	0	0
Total	20	27	6	**53**
Mean	**4**	**5.4**	**1.2**	

Table 10. Analysis of juvenile American shad otoliths collected in the Susquehanna River, 2004.

		Immersion marks											
		Day	Days	Days	Days	Days	Days	Days	Days	Days	Days		
				3,6,	3,9,12	3,6,9,	3,9,	3,6,9	3,6	3,6,9			
		3,9,12	3,6,9	12,15	15,18	15,18	12,15	12,15	9,15	12,18	3,15,18		
Collection Site	Coll. Date	Jun. R/ Susq. R	Jun. R/ Susq. R*	Conodo-guinet Cr.	W. Cone-wago Cr.	Swat-ara Cr.	Conest-oga Cr.	W. Br. Sus. R	N. Br. Sus. R (PA)	N. Br. Sus. R (NY)	Chemung	Total Hatchery	Total Wild
Columbia	8/31/2004	16	0	0	0	0	0	0	0	0	0	16	0
	9/7/2004	4	1	0	0	0	0	0	0	0	0	5	0
	9/9/2004	2	2	0	0	0	0	0	0	0	0	4	0
Holtwood		No shad collected											
Peach Bottom Impingement		No shad collected											
Conowingo Strainers		No shad collected											
Holt./P. Bot./Con.		0	0	0	0	0	0	0	0	0	0	0	0
Percent												0%	0%
Grand Total		22	3	0	0	0	0	0	0	0	0	25	0
Percent		88%	12%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%

*Susquehanna River source eggs.

Job V - Task 1

ANALYSIS OF ADULT AMERICAN SHAD OTOLITHS, 2004

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ABSTRACT

A total of 163 adult American shad otoliths were processed from adult shad sacrificed at the Conowingo Dam West Fish Lift in 2004. Based on tetracycline marking, 28% of the 158 readable otoliths were identified as wild and 72% were identified as hatchery in origin. No double marked fish (released below Conowingo Dam) were collected in the Conowingo West Lift samples.

Using age composition and otolith marking data, the lift catch was partitioned into its component year classes for both hatchery and wild fish. Results indicated that for the 1986-1997 year classes, stocking of approximately 178 hatchery larvae was required to return one adult to the lifts. For fingerlings, stocking of 133 fingerlings was required to return one adult to the lifts. For wild fish, transport of 0.81 adults to upstream areas was required to return one wild fish to the lifts. Actual survival is even higher since not all surviving adults enter the lifts.

INTRODUCTION

Efforts to restore American shad to the Susquehanna River have been conducted by the Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC). Primary restoration

approaches consisted of: (1) trapping of pre-spawn adults at Conowingo Dam and transfer to areas above dams (1972 to 1999), (2) direct fish passage (1997 to the present), and (3) planting of hatchery-reared fry and fingerlings.

In order to evaluate and improve the program, it was necessary to know the relative contribution of the hatchery program to the overall restoration effort. Toward that end, the Pennsylvania Fish Commission developed a physiological bone mark which could be applied to developing fry prior to release (Lorson and Mudrak, 1987; Hendricks et al., 1991). The mark was produced in otoliths of hatchery-reared fry by immersion in tetracycline antibiotics. Analysis of otoliths of outmigrating juveniles allows discrimination of "wild" vs. hatchery reared fish. The first successful application of tetracycline marking at Van Dyke was conducted in 1984. Marking on a production basis began in 1985 but was only marginally successful (Hendricks, et al., 1986). In 1986, 97.8% tag retention was achieved (Hendricks, et al., 1987) and analysis of outmigrants indicated that 83% of the upstream production (above Conowingo Dam) was of hatchery origin vs. 17% wild (Young, 1987). Similar data has been collected in subsequent years.

Determination of the contribution to the overall adult population below Conowingo of hatchery-reared and wild fish resulting from restoration efforts was more complicated. The adult population of shad below Conowingo Dam includes: (1) wild, upper bay spawning stocks which are a remnant of the formerly abundant Susquehanna River stock; 92) wild fish of upstream origin which are progeny of adults from out-of-basin or Conowingo trap and transfer efforts, (3) hatchery-reared fish originating from stockings in main stem or tributary areas upstream from

Conowingo Dam, and (4) hatchery-reared fish originating from stockings below the Conowingo Dam. The latter group were fish which received a "double" tetracycline mark and were planted below Conowingo Dam from 1986 to 1996.

Since mark retention did not approach 100% until 1987, adult hatchery shad from cohorts produced before 1987 did not exhibit 100% marking. For the years in which these fish returned to the river as adults, marking rates could therefore be used only to determine minimum contribution of hatchery-reared fish. For fish which did not exhibit a mark, otolith microstructure (Hendricks et al., 1994) was used to distinguish hatchery fish from wild fish.

METHODS

A representative sample of adult shad returning to Conowingo Dam was obtained by sacrificing every 50th shad which entered the West lift. Because the West Fish Lift was under repair during much of the season, these collections were supplemented with fish collected from anglers and used in tank-spawning trials. Adult American shad collected in the upper Chesapeake Bay by Maryland DNR were processed by MDNR staff and are not reported here.

Each sampled fish was sexed, measured and decapitated. Whole heads were frozen and delivered to the Van Dyke Hatchery. Otoliths (sagittae) were extracted and one otolith was mounted for mark analysis in Permount® on a microscope slide, while the other was mounted for ageing on clear tape in two-part, rod-building epoxy. For mark analysis, otoliths were ground on both sides to produce a thin sagittal section and the specimen examined under UV light for the presence of a tetracycline mark.

Whole otoliths were aged by viewing with a dissecting microscope and a fiber optic light. The best contrast was obtained by directing the light from the side, parallel to the sagittal plane of the otolith. Ageing was done by a single researcher. After initial ageing, length at age was analyzed and apparent outliers were re-examined. We have assembled a collection of several hundred otoliths from known-aged shad based on the presence of a unique tetracycline mark. These were used as reference material.

Historical fish lift catch data was compiled from SRAFRC Annual Progress Reports for the years 1972 through 2004. Age composition data was gathered as follows: for 1996 to 2003, age composition data were collected from the aforementioned otolith analysis. For 1991-1995, age composition data were taken from scale samples collected from the fish used for otolith analysis. These samples were collected by sacrificing every 100th fish collected in the lifts, and as such, represent a truly random sample. For 1989 and 1990, age composition data was determined from the overall fish lift database as reported in SRAFRC Annual Progress Reports by RMC Environmental Services. This database includes holding and transporting mortalities which skew the data slightly toward females and older fish (Hendricks, Backman and Torsello, 1991).

Recruitment to the lifts by year class was determined for hatchery and wild origin fish by partitioning the lift catch for each year into its component year classes based upon age composition and otolith marking data. Total recruitment by year class was determined for hatchery and wild groups by summing the data for each year class over its recruitment history. The number of larvae required to return one adult to the lifts (L/A) was determined for each year

class by dividing the number of larvae stocked above dams by the total recruitment of adults which originated as hatchery larvae. Similarly, the number of fingerlings required to return one adult (F/A) was determined for each year class by dividing the number of fingerlings stocked above dams by the total recruitment of adults which originated as hatchery fingerlings. The number of transported adults required to return one adult (TA/A) was determined for each year class by dividing the number of adults transported upstream by the total recruitment of unmarked (wild) adults. Overall L/A, F/A and TA/A were calculated by dividing the sum of the number stocked or transported by the sum of the total recruitment of the group, for the cohorts in question.

RESULTS AND DISCUSSION

A total of 163 shad was sacrificed for otolith analysis from Conowingo Dam in 2004. No samples were collected from the East Lift since it was operated in fish passage mode. There were five unreadable otoliths (Table 1). A total of 45 (28%) otoliths exhibited wild microstructure and no tetracycline mark. One hundred and thirteen (72%) exhibited tetracycline marks including single, triple, quadruple, and quintuple immersion marks. No specimens exhibited double marks or feed marks. Random samples of adults have been collected since 1989 and the results of the classifications are summarized in Table 2. The contribution of wild (naturally produced) fish to the adult population entering the Conowingo Dam fish lifts during 1989-2004 ranged from 10 to 71% (Table 2, Figure 1). Although the proportion of wild fish in the Conowingo Lift collections was low prior to 1996, the numbers of wild fish showed an increasing trend from 1989 to 2000 and have decreased since 2000 (Figure 2).

Length frequencies, age frequencies, mean total length, and mean weight are detailed in Tables 3 to 7. In general, age, length and weight have increased over time, with a slight decrease in 2004. Age distributions were similar for wild and hatchery fish. Sex ratios (Table 8) have ranged from 7:10 to 19:10 (males:females) with no trend over time. Tables 9 and 10 detail age and repeat spawning for otolith and scale ages. Repeat spawning has been highly variable, ranging from 1% in 2001 to 45% in 2002, however, determination of repeat spawning is an inexact science.

Fish lift catch, age composition and origin of sacrificed shad are presented in Table 11. Analysis of otoliths to assess hatchery contribution was not conducted prior to 1989. As a result, the catch for year classes prior to 1986 could not be partitioned into hatchery and wild and are not presented. Year classes after 1997 are not fully recruited and are not included in the analysis. For the period 1986-1997, the number of hatchery larvae required to produce one returning adult (L/A) ranged from 60 to 620, with an overall value of 178 (Table 12). L/A was highest (431-620) for the early cohorts (1986 – 1989). During 1990 to 1997, L/A improved to 60-289, presumably due to improvements in fish culture practices.

L/A was surprisingly low in comparison to the reproductive potential of wild fish. If fecundity of wild females is assumed to be 200,000, then 2 of 200,000 eggs must survive to maturity to replace the spawning pair in a stable population. If we assume a fertilization rate of 60% (comparable to strip-spawning), 60,000 fertilized eggs would be required to produce one wild adult at replacement. This suggests that mortality in the wild is extremely high during incubation and/or for the first week after hatch.

This analysis was repeated for fingerlings stocked above Conowingo Dam (Table 13). For the period 1986-1997, the number of hatchery fingerlings required to produce one returning adult (F/A) ranged from 40 to 386, with an overall value of 133. At first glance, it would appear that stocking fingerlings is advantageous over stocking larvae, however, on average, one must stock 100,000 larvae in a pond to harvest 10,000 to 20,000 fingerlings. Therefore, it would take 700 to 1,400 larvae, stocked in a pond, then harvested and stocked in the river as fingerlings to produce one adult. Considering the cost of pond culture, it is clearly better to stock larvae directly. In future years, F/A is unlikely to change since the last significant fingerling stockings were in 1994 and the last fingerlings recovered were in 1999. The appearance of 225 recruited adults for the 1995 cohort and 43 for the 1996 cohort, when no fingerlings were stocked, is an artifact of erroneous ageing, and highlights the problems with ageing American shad.

A similar analysis was tabulated for wild fish (Table 14). For the period 1986 to 1997, transport of an average of 0.81 adults was required to produce one returning adult, above the level required for replacement. The actual stock/recruitment ratio of wild fish is unknown since some of the wild fish which entered the lifts would have been of Upper Bay origin and not all recruited fish entered the lifts. These factors may act to cancel each other out, but the magnitude of each is not known.

Stress during trucking may account for reduced performance of transported spawners. The high fecundity of the species has the potential to overcome this, since just a few successful spawners can produce huge numbers of offspring. Another possible explanation is that there may be some threshold number of spawners required to ensure successful spawning. Whatever the

cause, stock/recruitment ratios are improving in recent years and must continue to do so to allow for successful restoration.

Virtual survival rates by cohort and stocking site are reported in Table 15. As expected, some cohorts survived better than others, probably due to environmental conditions. The 1996 cohort exhibited the highest virtual survival rate (146) followed by 1997 (133) and 1995 (73). The 1998-2000 cohorts are not yet fully recruited.

Adult relative survival for individual stocking sites was highly variable between cohorts (Table 15). For example, relative survival for the Juniata River/Juniata or middle Susquehanna sites ranged from 0.19 to 0.99. For the North Branch Susquehanna River the range was from 0.22 to 0.46. For West Conewago Creek, relative survival ranged from 0.00 to 1.00. For Swatara Creek, relative survival ranged from 0.00 to 0.37. For Conodoguinet Creek, relative survival ranged from 0.00 to 1.00. Conodoguinet Creek exhibited the highest survival for both the 1997 and 1999 cohorts and a very high relative survival (0.83) for the 1996 cohort. Both adult and juvenile relative survival rates were consistently poor for the West Branch Susquehanna River.

Stocking site/cohort specific relative survival of juvenile shad was correlated to that for adult shad (Figure 3) but the relationship was not significant ($p=0.229$). This result is counter-intuitive since it is logical to assume that groups which exhibited better survival as juveniles would also exhibit better survival as adults. Either survival to the juvenile stage has no strong relationship to survival to adulthood, one of the recapture samples are not representative of the

population, or errors in aging resulted in incorrect partitioning of the lift catch which had the effect of randomizing the data. It is difficult to believe that stocking site carries with it some survival advantage (or disadvantage) which is expressed between the fall outmigration, when juveniles are recaptured, and the spring spawning migration, when returning adults are recaptured several years later. It is equally unlikely that the Conowingo Fish Lifts select for or against adult shad based on the site where they were stocked. It seems more likely that collections of juveniles at Holtwood, Peach Bottom and Conowingo somehow select for or against fish based on stocking site, however the mechanism by which that occurs is not known. Perhaps distance between the stocking site and juvenile recapture site, coupled with river flow and migration rate are somehow interacting to produce a recapture sample that is not representative of the population. Errors in otolith aging certainly occur and can be as much as 30 to 40% (unpublished data based on known age specimens from the Lehigh River). Aging errors, coupled with small sample size in some of the recapture groups (Table 15) could explain the lack of correlation between juvenile and adult survival.

It is interesting that a similar phenomenon was detected when analyzing recaptures of shad marked according to egg source river. For the 1989 to 1994 cohorts, relative survival of juveniles from Hudson River source larvae was always 1.00, while relative survival of Delaware River source larvae ranged from 0.06 to 0.83 with a mean of 0.29 (Hendricks, 2001). Clearly, Hudson River source juveniles were recaptured at a much higher rate than Delaware River source juveniles. When recapture rates of adults at the Conowingo Fish Lifts were analyzed, the trend was reversed. Relative survival of Delaware source adults ranged from 0.83 to 1.00 with a mean of 0.96, compared to a range of 0.29 to 1.00 and a mean of 0.75 for Hudson River adults. This analysis was also dependent upon correct aging. It is possible that aging errors were the cause of

both of these anomalous observations. For this reason, marking protocols for 2004 and beyond included an alternating marking scheme to provide known age specimens (see Job III).

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Figure 1. Estimated composition of adult Amercian shad caught at Conowingo Dam, based on otolith microstructure and tetracycline marking.

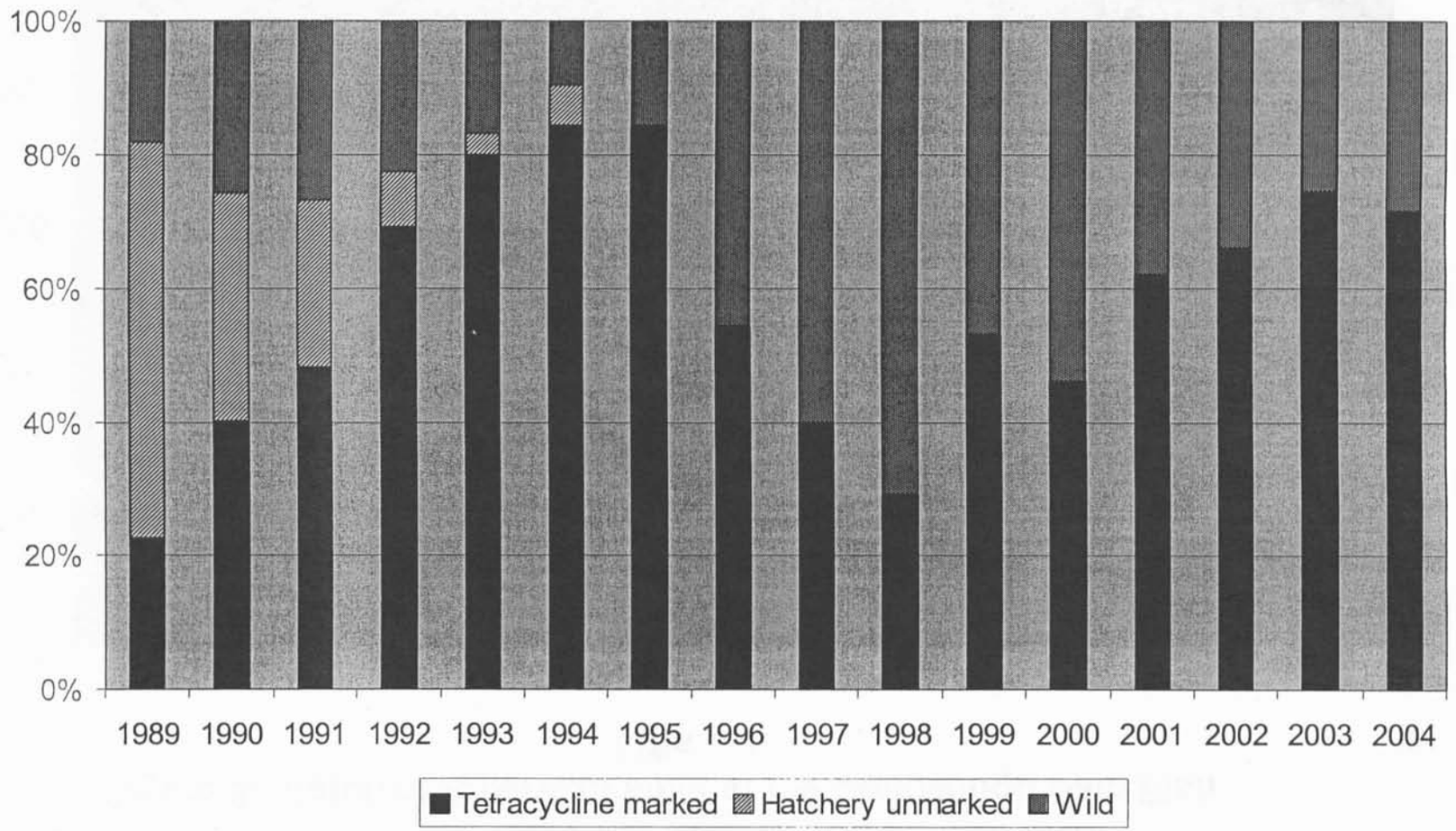

Figure 2. Catch of American shad at the Conowingo Dam Fish Lifts.

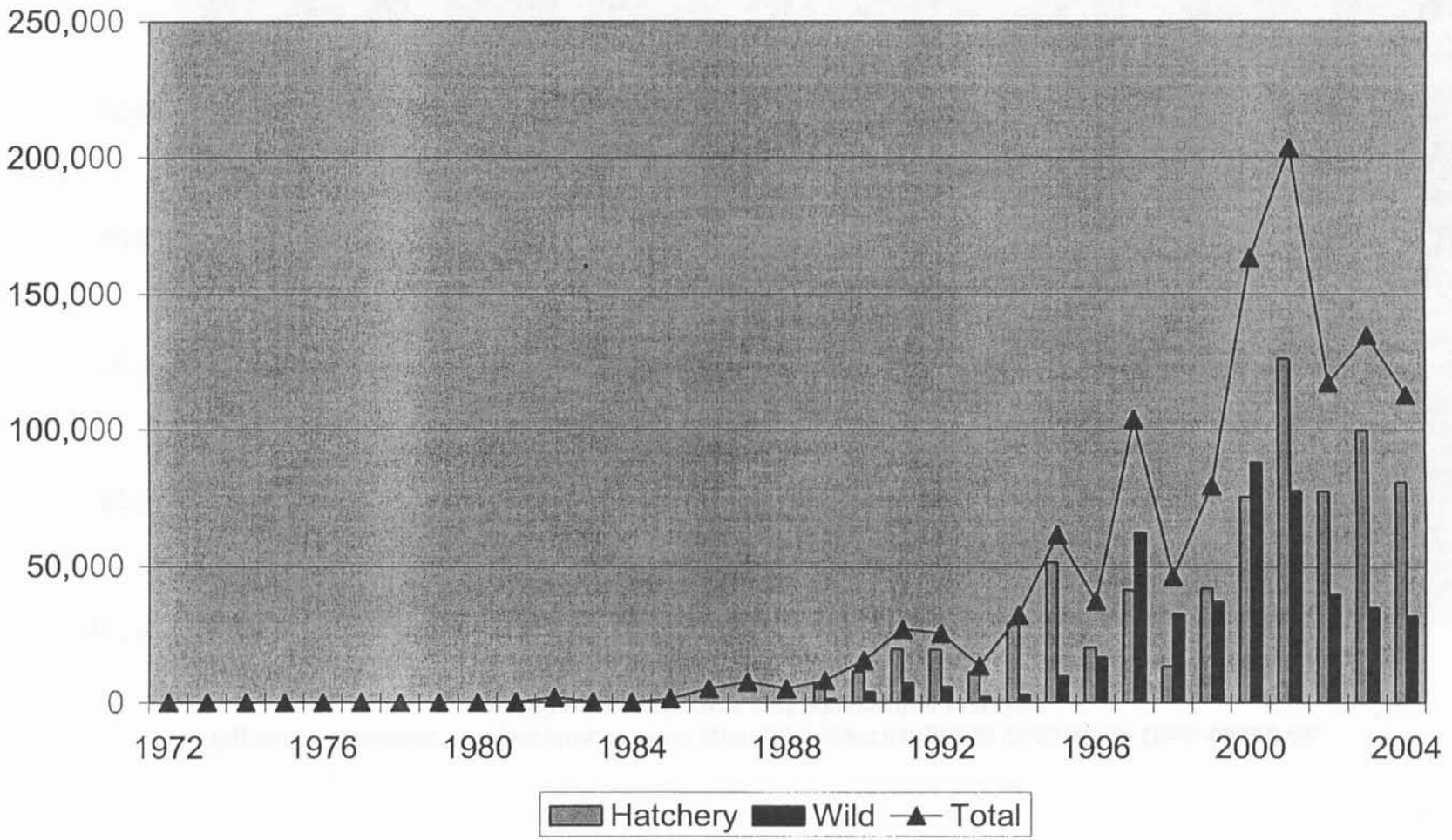

Figure 3. Stocking site/cohort specific relative survival of juvenile shad vs. adult shad, Susquehanna River, 1995-2000.

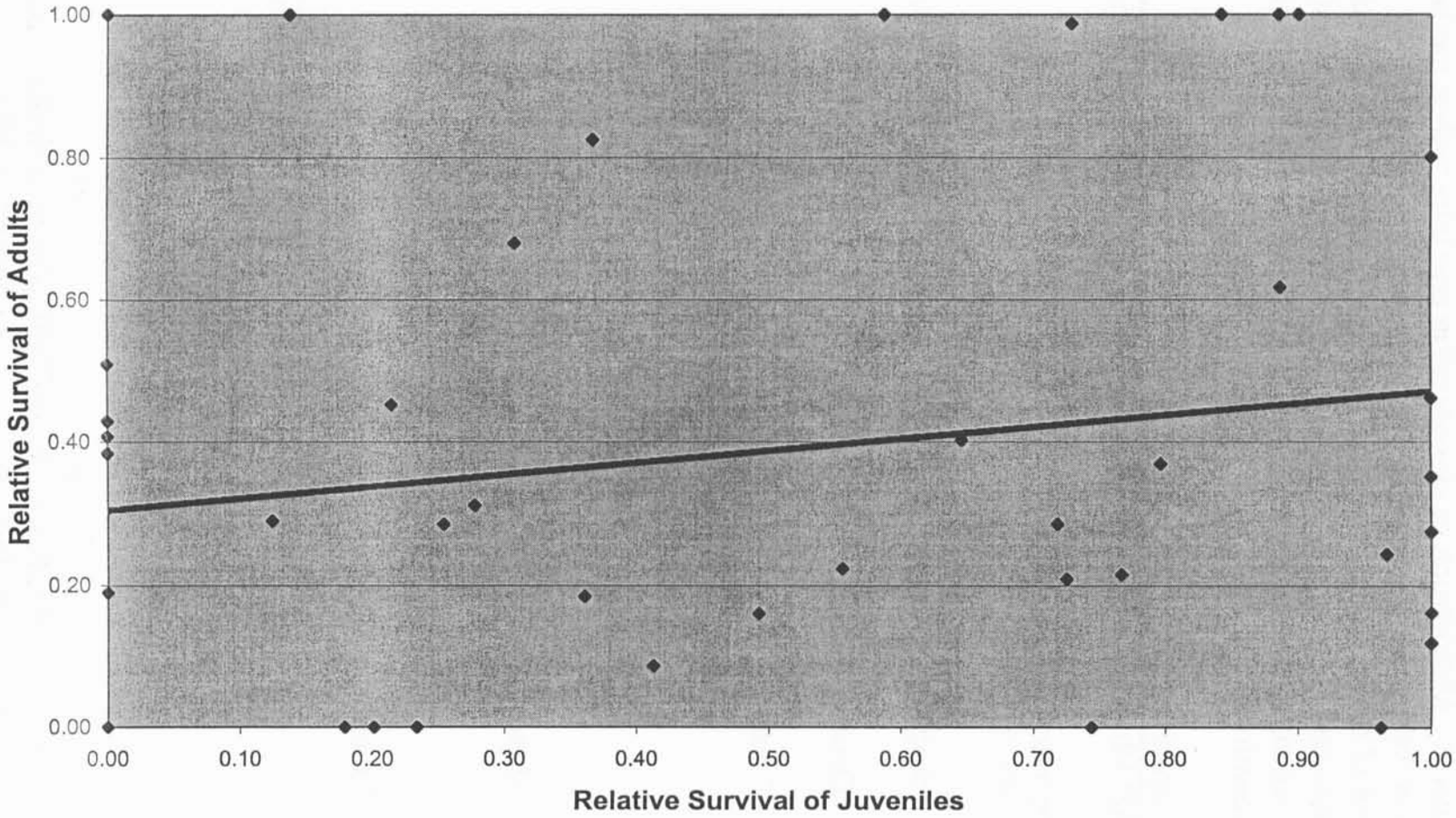

Table 1. Microstructure classification and tetracycline marking of adult American shad collected in the Susquehanna River, 2004.
One of every 50 fish collected from the Conowingo West Fish Lift was sacrificed for analysis. Due to major downtime for the West Fish Lift, these collections were supplemented by including 95 fish used in tank spawning trials.

Conowingo Dam		N	%
Wild Microstructure, No TC Mark		45	28%
Hatchery Microstructure			
No TC Mark*		0	0%
Single TC Mark	Day 3 or 5	88	56%
Double TC Mark	Days 5,9, 3,6 or 3,7		0%
Triple TC Mark	Days 3,6,9	3	2%
	Days 5,9,13	1	1%
	Days 3,13,17	6	4%
	Days 3,9,12	1	1%
	Days 9,12,15	1	1%
Quadruple TC Mar	Days 3,13,17,21		0%
	Days 3,6,9,12	7	4%
	Days 3,9,12,15	2	1%
Quintuple TC Mark	Days 3,6,9,15,18		0%
	Days 3,6,12,15,18	4	3%
	Total Hatchery	113	72%
	Total readable otolith	158	
	Unreadable Otoliths*	5	
	Total	163	

*Includes poor grinds and otoliths with autofluoresence obscuring mark.
**Includes missing, broken and poorly ground otoliths.

Table 2. Origin of adult American shad collected at Conowingo Dam Fish Lifts, based on otolith analysis.

		Hatchery									
	Sample:	Larvae									
	One			below					Naturally		Total
	in	Susquehanna		Conowingo Dam		Fingerling		Unmarked**	reproduced		sample
Year	??	N	%*	N	%*	N	%*	N	N	%	size
1989	50	36	82	-		-		94	29	18	159
1990	100	49	73	1	1	-		42	32	26	124
1991	100	111	67	8	5	3	2	63	68	27	253
1992	100	154	73	8	4	2	1	19	54	23	237
1993	100	76	64	21	18	2	2	4	21	17	124
1994	100	217	81	22	8	3	1	17	28	10	287
1995	100	255	77	19	6	4	1	1	52	16	331
1996	100	180	48	22	6	4	1	1	172	45	379
1997	50	84	34	12	5	4	2	0	150	60	250
1998	50	29	22	7	5	2	2	0	92	71	130
1999	50	90	48	9	5	1	1	0	88	47	188
2000	50	78	40	11	6	0	0	0	104	54	193
2001	50	120	58	9	4	0	0	0	79	38	208
2002	50	118	65	2	1	0	0	0	62	34	182
2003	50	146	74	0	0	0	0	0	50	26	196
2004	50	113	72	0	0	0	0	0	45	28	158
Totals		1,856	61	151	5	25	1	241	1,126	33	3,399

*Unmarked hatchery fish distributed among groups based on annual percentage.
**Distinguished from naturally-reproduced fish by otolith microstructure.

Table 3. Length-frequency of American shad collected in the Susquehanna River at the Conowingo West Fish Lift, 1993-2004.

Males

TL - mm	1993	1995*	1996*	1997*	1998*	1999*	2000*	2001	2002	2003	2004
250											1
275											
300	2										
325	3	1									
350	17	1	2			1					2
375	17	18	11	12	1	8		1	2		5
400	18	31	45	48	6	13	7	4	11	8	2
425	27	80	56	47	13	40	32	5	5	12	14
450	6	107	44	34	26	22	55	20	9	27	15
475		71	32	24	19	15	27	34	14	24	19
500		18	13	6	2	4	12	20	24	12	12
525		4	9	1	1	1	3	1	8		3
550		2	2						2		1
575										2	
600											
625			1								
650											
675											
Total	90	333	215	172	68	104	136	85	75	85	74

Females

TL - mm	1993	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
250											
275											
300											
325											
350		1									
375	3	1	2			1					
400	9		2	2							
425	7	2	1	3		3					1
450	7	6	11	4	4	12	3	3	1	5	4
475	14	64	28	28	11	20	14	16	4	11	10
500	4	91	36	20	27	26	12	36	14	14	24
525	1	47	49	12	24	14	21	39	32	19	26
550		14	17	10	6	8	5	18	42	21	12
575		8	7	3		4	4	2	15	23	11
600		2							4	7	
625		1				1				1	
650											
675										1	
Total	45	237	153	82	72	89	59	114	112	101	88

Table 3. (continued).

Sexes Combined

TL - mm	1993	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
250											1
275											
300	2										
325	3	1									
350	17	2	2			1					2
375	20	19	13	12	1	9		1	2		5
400	27	31	47	50	6	13	7	4	11	8	2
425	34	82	57	50	13	43	32	5	5	12	15
450	13	113	55	38	30	34	58	23	10	32	19
475	14	135	60	52	30	35	41	50	18	35	29
500	4	109	49	26	29	30	24	56	38	26	36
525	1	51	58	13	25	15	24	40	40	19	29
550		16	19	10	6	8	5	18	44	21	13
575		8	7	3		4	4	2	15	25	11
600		2							4	7	
625		1	1			1				1	
650											
675										1	
Total	135	570	368	254	140	193	195	199	187	187	162

*TL estimated from FL according to: TL= FL * 1.117 + 6.674

Table 4. Age-frequency of American shad collected in the Susquehanna River at the Conowingo West Fish Lift, 1996-2004.

Wild Males

Otolith Age	1996	1997	1998	1999	2000	2001	2002	2003	2004
2	3								
3	54	33	1	11	12	2	6	2	8
4	41	58	27	22	48	12	3	8	5
5	15	5	17	8	8	11	7	7	6
6		3			2	2	3	5	2
7								1	3
8									1
9									
??	8								
Total	121	99	45	41	70	27	19	23	25
Mean Age	3.6	3.8	4.4	3.9	4.0	4.5	4.4	4.8	4.6

Hatchery Males

Otolith Age	1996	1997	1998	1999	2000	2001	2002	2003	2004
2	1								
3	25	28	3	8.0	7	2	10	2	5
4	29	24	9	40	37	17	12	41	7
5	32	12	10	8	17	31	24	10	27
6	1	2		2	3	5	6	12	6
7	2						2	1	2
8				1				1	
9							1		
??	2	2		1			1	2	
Total	92	68	22	60	64	55	56	69	47
Mean Age	4.1	3.8	4.3	4.1	4.3	4.7	4.5	4.6	4.9

Wild Females

Otolith Age	1996	1997	1998	1999	2000	2001	2002	2003	2004
2									
3	3	2			1				
4	20	23	8	14	11	11	5	4	1
5	14	16	28	22	13	27	14	7	9
6	6	9	9	8	6	10	18	11	3
7			1	1			4	4	5
8							1		1
9									
??	6			2			1		
Total	49	50	46	47	31	48	43	26	19
Mean Age	4.5	4.6	5.1	4.9	4.8	5.0	5.6	5.6	5.8

Hatchery Females

Otolith Age	1996	1997	1998	1999	2000	2001	2002	2003	2004
2		1							
3								1	
4	24	5	4	10	2	7	8	8	4
5	60	11	6	24	14	29	29	23	34
6	10	12	5	5	8	24	24	33	13
7	5	2		1	2	4	5	9	13
8							2	1	1
9									
??	6	1		2			1		
Total	105	32	15	42	26	64	69	75	65
Mean Age	5.0	5.3	5.1	4.9	5.4	5.4	5.5	5.6	5.5

Table 5. Mean Total length and weight of adult American shad collected at the Conowingo Dam West Fish Lift, 1993-2004.

Males	1993	1995*	1996*	1997*	1998*	1999*	2000*	2001	2002	2003	2004
N	90	333	215	172	68	104	136	85	75	95	74
Total Length (mm)	404	456	452	441	461	445	465	479	481	474	463
SD	36	33	41	32	26	32	26	28	44	36	48
N		333	208	172	68	104	136	86	75	95	75
Weight (g)		889	808	797	783	739	862	912	1041	1032	947
SD		205	227	187	149	145	169	180	303	293	255
Females											
N	45	237	156	82	62	89	59	114	112	102	88
Total Length (mm)	457	513	507	509	519	478	493	524	550	547	528
SD	37	32	79	38	27	40	32	25	27	44	34
N		237	150	82	62	89	59	114	112	101	88
Weight (g)		1371	1413	1441	1295	1201	1346	1372	1618	1735	1474
SD		284	292	349	261	251	292	215	347	443	315
Combined											
N	135	624	371	254	130	193	195	199	187	197	163
Total Length (mm)	422	479	475	463	489	474	483	505	523	512	498
SD	44	43	66	47	39	47	39	34	49	54	52
N		624	358	254	130	193	195	200	187	196	164
Weight (g)		1090	1062	1005	435	966	1026	1174	1387	1394	1232
SD		342	394	392	331	318	327	304	434	516	390

Table 6. Mean total length (mm) at age for American shad collected at the Conowingo Dam West Fish Lift, 1995-2004.

Otolith age	1995*	1996*	1997*	1998*	1999*	2000*	2001	2002	2003	2004
Male										
2		392								
3	410	424	416	431	420	454	478	419	429	366
4	445	463	447	454	443	460	465	471	458	387
5	466	484	488	473	472	488	486	502	488	430
6	477	526	481		482	515	494	527	512	444
7	529	492					480	509	510	477
8					509				512	410
9								536		
Female										
2			426							
3			442						450	
4	492	504	486	491	499	500	506	528	489	445
5	511	526	515	521	508	526	521	547	540	461
6	515	473	538	539	521	541	537.5	554	560	486
7	566	533	560	495	540	549	537	580	579	495
8								579	570	498
9										

Scale age	1995*	1996*	1997*	1998*	1999*	2000*	2001	2002	2003	2004
Male										
2										
3						453	447	418	440	366
4						463	481	470	467	397
5	scales not read					488	488	502	495	434
6						516	500	522	518	448
7								509		477
8										410
9										
Female										
2										
3						461	510		470	
4						512	511	528	508	450
5						518	527	545	545	461
6	scales not read					550	548	554	577	490
7						587	551	580	600	494
8								568	570	498
9									620	

*TL estimated from FL according to: TL= FL * 1.117 + 6.674

Table 7. Mean weight (g) at age for American shad collected at the Conowingo Dam West Fish Lift, 1995-2004.

Otolith

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Male										
2		546								
3	610	662	667	614	642	838	949	669	740	590
4	840	869	834	750	717	828	831	986	918.9	834
5	936	967	1022	861	855	983	956	1126	1090	1025
6	1022	1220	1018		885	1195	1009	1413	1336	1094
7	1293	970					795	1280	1335	1402
8					1130				1180	1020
9								1380		
Female										
2			1400							
3			950						1000	
4	1162	1344	1233	1012	1154	1227	1247	1383	1216	1250
5	1343	1440	1524	1311	1234	1425	1340	1619	1726	1345
6	1418	1513	1647	1474	1382	1495	1496	1657	1817	1572
7	1826	1321	1695	1210	1500	1885	1460	1841	1989	1739
8								1675	2080	1715
9										

Scale

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Male										
2										
3						809	728	670	810	600
4						840	923	960	967	869
5	scales not read					1018	983	1155	1196	1047
6						1128	1060	1333	1365	1106
7								1280		1402
8										1020
9										
Female										
2										
3						915	1355		1103	
4						1322	1284	1391	1406	1297
5						1369	1399	1590	1732	1347
6	scales not read					1562	1638	1690	1946	1610
7						2230	1080	1726	2218	1722
8								1703	2080	1715
9									2550	

Table 8. Sex ratio of American shad collected at the Conowingo Dam West Fish Lift, 1997-2004.

	1997	1998	1999	2000	2001	2002	2003	2004
Male:Female	19:10	9:10	9:10	23:10	7:10	12:10	9:10	12:10

Table 9. Otolith age and repeat spawning for American shad collected in the Conowingo Dam West Fish Lift, 2000-2004.

Male	Otolith Age	2	3	4	5	6	7	8	9	Total	%
2000	0		18	77	17	2				114	89%
Repeats	1			3	4	3				10	8%
	2				4					4	3%
	3									0	0%
	4									0	0%
	TOTAL		18	80	25	5				128	
2001	0		3	30	38	7	1			79	99%
Repeats	1				1					1	1%
	2									0	0%
	TOTAL		3	30	39	7	1			80	
2002	0		16	9	12	4				41	58%
Repeats	1			5	13	3				21	30%
	2				4	2	2		1	9	13%
	TOTAL		16	14	29	9	2			71	
2003	0		4	44	17	17	2			84	95%
Repeats	1			3				1		4	5%
	2									0	0%
	TOTAL		4	47	17	17	2	1		88	
2004	0		13	13	27	7	3	1		64	86%
Repeats	1				7	1	1			9	12%
	2						1			1	1%
	TOTAL		13	13	34	8	5	1		74	

Table 9. (continued).

Female	Otolith Age	2	3	4	5	6	7	8	9	Total	%
2000	0		1	13	19	11	1			45	79%
Repeats	1				4					4	7%
	2				3	3				6	11%
	3						1			1	2%
	4				1					1	2%
	TOTAL		1	13	27	14	2			57	
2001	0			16	51	30	4			101	100%
Repeats	1									0	0%
	2									0	0%
	TOTAL			16	51	30	4			101	
2002	0			11	19	21	5	1		57	53%
Repeats	1			2	19	15	4	2		42	39%
	2				4	5				9	8%
	TOTAL			13	42	41	9	3		108	
2003	0		1	12	24	40	9	1		87	86%
Repeats	1				3	2	2			7	7%
	2				3	2	2			7	7%
	TOTAL		1	12	30	44	13	1		101	
2004	0			5	37	14	12			68	79%
Repeats	1				5	2	4			11	13%
	2				1	1		1		3	3%
	3						3			3	3%
	4							1		1	1%
	TOTAL			5	43	17	19	2		86	

Sexes Combined	Otolith Age	2	3	4	5	6	7	8	9	Total	%
2000	0		19	90	36	13	1			159	86%
Repeats	1			3	8	3				14	8%
	2				7	3				10	5%
	3						1			1	1%
	4				1					1	1%
	TOTAL		19	93	52	19	2			185	
2001	0		3	46	89	37	5			180	99%
Repeats	1				1					1	1%
	2										0%
	TOTAL		3	46	90	37	5			181	
2002	0		16	20	31	25	5	1		98	55%
Repeats	1			7	32	18	4	2		63	35%
	2				8	7	2		1	18	10%
	TOTAL		16	27	71	50	11	3	1	179	
2003	0		5	56	41	57	11	1		171	90%
Repeats	1			3	3	2	2	1		11	6%
	2				3	2	2	0		7	4%
	TOTAL		5	59	47	61	15	2		189	
2004	0		13	18	64	21	15	1		132	83%
Repeats	1				12	3	5			20	13%
	2				1	1	1	1		4	3%
	3						3			3	2%
	4							1		1	1%
	TOTAL	0	13	18	77	25	24	3	0	160	

Table 10. Scale age and repeat spawning for American shad collected in the Conowingo Dam West Fish Lift, 2000-2004.

Male	Scale Age	2	3	4	5	6	7	8	9	Total	%
2000	0		37	65	14	1				117	89%
Repeats	1			5	4	1				10	8%
	2				4					4	3%
	3									0	0%
	4									0	0%
	TOTAL		37	70	22	2				131	
2001	0		10	45	23	1				79	99%
Repeats	1				1					1	1%
	2									0	0%
	TOTAL		10	45	24	1				80	
2002	0		15	12	10	5				42	58%
Repeats	1			5	12	4				21	29%
	2				3	4	2			9	13%
	TOTAL		15	17	25	13	2			72	
2003	0		17	41	20	9				87	96%
Repeats	1			3		1				4	4%
	2									0	0%
	TOTAL		17	44	20	10				91	
2004	0		13	18	23	6	3	1		64	86%
Repeats	1			2	5	1	1			9	12%
	2						1			1	1%
	TOTAL		13	20	28	7	5	1		74	

Female	Scale Age	2	3	4	5	6	7	8	9	Total	%
2000	0		2	14	17	11				44	76%
Repeats	1			2	3	1				6	10%
	2				4	2				6	10%
	3					1				1	2%
	4						1			1	2%
	TOTAL		2	16	24	15	1			58	
2001	0		1	35	54	11	1			102	100%
Repeats	1									0	0%
	2									0	0%
	TOTAL		1	35	54	11	1	0		102	
2002	0			12	22	18	4	1		57	52%
Repeats	1			3	19	16	5			43	39%
	2				4	5		1		10	9%
	TOTAL			15	45	39	9	2		110	
2003	0		5	17	36	23	5	1		87	86%
Repeats	1			1	4	1			1	7	7%
	2				3	4				7	7%
	TOTAL		5	18	43	28	5	1	1	101	
2004	0			9	37	13	11			70	80%
Repeats	1			1	4	2	4			11	13%
	2				1	1		1		3	3%
	3						3			3	3%
	4							1		1	1%
	TOTAL			10	42	16	18	2		88	

Table 10. (continued).

Sexes Combined	Scale Age	2	3	4	5	6	7	8	9	Total	%
2000	0		39	79	31	12				161	85%
Repeats	1			7	7	2				16	8%
	2				8	2				10	5%
	3					1				1	1%
	4						1			1	1%
	TOTAL		39	86	46	17	1			189	
2001	0		11	80	77	12	1			181	99%
Repeats	1				1					1	1%
	2									0	0%
	TOTAL		11	80	78	12	1			182	
2002	0		15	24	32	23	4	1		99	54%
Repeats	1			8	31	20	5			64	35%
	2				7	9	2	1		19	10%
	TOTAL		15	32	70	52	11	2		182	
2003	0		22	58	56	32	5	1		174	91%
Repeats	1			4	4	2			1	11	6%
	2				3	4				7	4%
	TOTAL		22	62	63	38	5	1	1	192	
2004	0		13	27	60	19	14	1		134	83%
Repeats	1			3	9	3	5			20	12%
	2				1	1	1	1		4	2%
	3						3			3	2%
	4							1		1	1%
	TOTAL	0	13	30	70	23	23	3	0	162	

Table 11. Age composition and origin of American shad collected at the Conowingo Dam Fish Lifts, 1988-2004.

										Hatchery Release Site			Wild
										Above Dams		Below Dams	
	Fish lift	% Age composition								larvae	fingerlings		
Year	catch	9	8	7	6	5	4	3	2	%	%	%	%
1988	5,146	0.0	0.0	4.0	31.7	38.1	21.2	4.7	0.4	71% *		6% *	23%
1989	8,218	0.0	0.0	4.3	18.1	41.5	30.2	5.6	0.2	82%			18%
1990	15,719	0.0	0.1	5.5	32.7	45.2	15.0	1.5	0.0	73%		1%	26%
1991	27,227	0.0	0.0	10.7	36.7	38.4	12.4	1.7	0.0	67%	2%	5%	27%
1992	25,721	0.0	0.6	12.3	35.7	36.8	11.7	2.9	0.0	73%	1%	4%	23%
1993	13,546	0.0	0.0	3.2	21.6	52.8	21.6	0.8	0.0	64%	2%	18%	17%
1994	32,330	0.0	0.0	3.3	22.6	54.7	19.3	0.0	0.0	81%	1%	8%	10%
1995	61,650	0.0	0.0	3.2	12.4	51.9	28.5	4.0	0.0	77%	1%	6%	16%
1996	37,513	0.0	0.0	0.8	16.1	41.5	33.6	7.6	0.3	48%	1%	6%	45%
1997	103,945	0.0	0.0	0.0	10.5	18.1	44.8	26.2	0.4	34%	2%	5%	60%
1998	46,481	0.0	0.0	0.8	10.9	48.1	37.2	3.1	0.0	22%	2%	5%	71%
1999	79,370	0.0	0.5	1.1	8.1	33.5	46.5	10.3	0.0	48%	1%	5%	47%
2000	163,331	0.0	0.0	1.0	9.9	27.6	51.0	10.4	0.0	40%	0%	6%	54%
2001	203,776	0.0	0.0	2.0	21.4	50.5	24.0	2.0	0.0	56%	0%	4%	38%
2002	117,348	0.5	1.6	6.0	27.7	40.2	15.2	8.7	0.0	65%	0%	1%	34%
2003	134,937	0.0	1.0	7.2	31.4	25.8	32.0	2.6	0.0	74%	0%	0%	26%
2004	112,786	0.0	1.9	14.9	15.5	48.4	11.2	8.1	0.0	72%	0%	0%	28%

*No estimate of hatchery contribution available, used mean of 1989-1996.

Table 12. Recruitment of hatchery larvae, stocked above dams, to the Conowingo Fish Lifts, 1986- 1997.

	Cohort											
Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1988	13											
1989	373	16										
1990	1,706	166	0									
1991	6,956	2,250	307	0								
1992	6,652	6,870	2,181	545	0							
1993	277	1,867	4,563	1,867	69	0						
1994	0	859	5,918	14,318	5,059	0	0					
1995		0	1,517	5,907	24,746	13,570	1,916	0				
1996			0	152	2,881	7,430	6,015	1,365	51			
1997				0	0	3,676	6,363	15,695	9,191	141		
1998					0	80	1,125	4,983	3,858	322	0	
1999						205	411	3,081	12,734	17,663	3,902	0
2000							0	688	6,532	18,221	33,692	6,876
2001								0	2,339	24,562	57,897	27,486
2002								413	1,240	4,548	21,088	30,599
2003									0	1,029	7,204	31,389
2004										0	1,503	12,024
Total recruits to lifts:	15,977	12,028	14,486	22,789	32,755	24,963	15,830	26,225	35,945	66,487	125,287	108,374
Larval releases (millions):	9.90	5.18	6.45	13.46	5.62	7.22	3.04	6.54	6.42	10.00	7.47	8.02
Number of larvae to return 1 adult:	620	431	445	591	172	289	192	249	179	150	60	74

Overall number of larvae to return 1 adult (1986-1997): 178

Table 13. Recruitment of hatchery fingerlings, stocked above dams, to the Conowingo Fish Lifts, 1986- 1997.

	Cohort											
Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1988	3 *											
1989	0	0										
1990	0	0	0									
1991	188	61	8	0								
1992	86	89	28	7	0							
1993	7	49	120	49	2	0						
1994	0	12	82	198	70	0	0					
1995		0	24	93	388	213	30	0				
1996			0	3	64	165	134	30	1			
1997				0	0	174	302	744	436	7		
1998					0	6	78	344	266	22	0	
1999						2	5	34	141	196	43	0
2000							0	0	0	0	0	0
2001								0	0	0	0	0
2002								0	0	0	0	0
2003									0	0	0	0
2004										0	0	0
Total recruits to lifts:	285	211	262	350	524	560	548	1,153	845	225	43	0
Fingerlings stocked/10,000:	7.25	8.15	6.40	6.04	9.00	5.44	2.18	7.94	13.95	0.00	0.00	2.50
fingerlings to return 1 adult:	255	386	244	172	172	97	40	69	165	0	0	0

Overall number of fingerlings to return 1 adult (1986-1996): 133

Table 14. Recruitment of naturally reproduced American shad to the Conowingo Fish Lifts, 1986-1997.

	Cohort											
Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1988	55 *											
1989	83	4										
1990	607	59	0									
1991	2,811	910	124	0								
1992	2,091	2,159	685	171	0							
1993	73	496	1,211	496	18	0						
1994	0	104	714	1,727	610	0	0					
1995		0	308	1,201	5,029	2,758	389	0				
1996			0	144	2,741	7,069	5,723	1,298	48			
1997				0	0	6,538	11,317	27,914	16,346	251		
1998					0	255	3,570	15,810	12,240	1,020	0	
1999						201	402	3,012	12,451	17,271	3,816	0
2000							0	917	8,710	24,295	44,923	9,168
2001								0	1,580	16,585	39,093	18,559
2002								217	652	2,390	11,080	16,077
2003									0	362	2,534	11,040
2004										0	599	4,788
Total recruits to lifts:	5,721	3,730	3,043	3,738	8,399	16,822	21,400	49,169	52,026	62,174	102,044	59,633
Adults passed or transported/1000*:	4.17	7.20	4.74	6.47	15.08	24.66	15.67	11.72	28.68	56.37	33.83	103.95
adults transported to return 1 adult:	0.73	1.93	1.56	1.73	1.79	1.47	0.73	0.24	0.55	0.91	0.33	1.74

Overall number of adults transported to return 1 adult (1986-1997): 0.81

Table 15. Virtual survival rates of marked American shad, by stocking site, recaptured as adults at the Conowingo Dam West Fish Lift.
Virtual Survival rate = Recruitment to the Conowingo Fish Lifts X 10,000, divided by the number stocked.

Cohort	Number Stocked (M)	Stocking location	Egg source	Number Recaptured (R)	Recruitment to Conowingo Fish Lifts	Virtual Survival Rate	Cohort Virtual Survival Rate	Adult Relative Virtual Survival Rate	Juvenile Relative Survival Rate
1995	9,070,999	Juniata or middle Susq.	Hud./Del.	93	66,229	73		0.40	0.65
1995	220,000	Conodoguinet Cr.	Hudson	1	860	39		0.22	0.77
1995	230,000	Conodoguinet (mouth)	Hudson	7	4,175	182		1.00	0.90
1995	198,000	Conestoga R.	Hudson	1	429	22		0.12	1.00
1995	190,000	Conestoga (mouth)	Hudson	1	638	34		0.18	0.36
1995	93,000	Muddy Cr.	Hudson	1	860	92		0.51	0.00
1995	520,000	below Conowingo (mid-channel)	Hud./Del.	6	3,847	74		0.41	0.00
1995	411,000	below Conowingo (nearshore)	Hud./Del.	6	2,862	70	73	0.38	0.00
1996	5,730,000	Juniata or middle Susq.	Delaware	117	96,643	169		0.68	0.31
1996	561,000	West Br. Susq. R.	Hud./Del.	5	4,337	77		0.31	0.28
1996	683,000	North Br. Susq. R.	Hudson	10	7,819	114		0.46	1.00
1996	172,000	Conodoguinet Cr.	Delaware	4	3,521	205		0.83	0.37
1996	277,000	Conestoga R.	Delaware	0	0	0		0.00	0.00
1996	43,000	Standing Stone Cr.	Delaware	2	1,067	248		1.00	0.00
1996	1,087,000	below Conowingo	Hud./Del./Susq.	13	11,563	106	146	0.43	0.00
1997	3,037,000	Juniata or middle Susq.	Hud./Del.	85	62,744	207		0.62	0.89
1997	2,270,000	Juniata	Hud./Del.	30	20,872	92		0.27	1.00
1997	486,000	Jun. R. (Huntingdon)	Hudson	5	3,399	70		0.21	0.72
1997	622,000	West Br. Susq. R.	Hudson	2	1,821	29		0.09	0.41
1997	1,199,000	North Br. Susq. R.	Hud./Del.	13	9,760	81		0.24	0.97
1997	174,000	Conodoguinet Cr.	Delaware	8	5,821	335		1.00	0.14
1997	231,000	Conestoga R.	Hudson	3	2,237	97	133	0.29	0.12
1998	8,925,000	Jun. & Susq. R.	Hud./Del.	54	37,424	42		0.29	0.72
1998	321,000	W. Conewago Cr.	Hudson	7	4,714	147		1.00	0.89
1998	565,000	Juniata R.	Susq.	2	1,333	24		0.16	0.49
1998	305,000	Conodoguinet Cr.	Hudson	2	1,276	42		0.28	0.25
1998	1,126,000	North Br. Susq. R.	Hudson	8	5,809	52		0.35	1.00
1998	229,000	Conestoga R.	Hudson	1	638	28		0.19	0.00
1998	230,000	Swatara Cr.	Hudson	0	0	0		0.00	0.96
1998	56,000	West Br. Susq. R.	Susq.	0	0	0	44	0.00	0.00
1999	10,229,000	Juniata R.	Hud./Del.	109	76,337	75		0.99	0.73
1999	373,000	Conodoguinet Cr.	Hudson	4	2,819	76		1.00	0.59
1999	984,000	W. Br. Susq. R.	Hudson	0	0	0		0.00	0.00
1999	236,000	Conestoga R.	Hudson	2	1,428	60		0.80	1.00
1999	219,000	W. Conewago Cr.	Hudson	0	0	0		0.00	0.20
1999	249,000	Swatara Cr.	Hudson	1	696	28		0.37	0.80
1999	1,211,000	N. Br. Susq. R.	Hudson	6	4,134	34	63	0.45	0.21
2000	7,369,000	Juniata & Susq. R.	Hudson	11	7,797	11		0.16	1.00
2000	111,000	Conodoguinet Cr.	Hudson	0	0	0		0.00	0.74
2000	109,000	W. Conewago Cr.	Hudson	1	714	65		1.00	0.84
2000	961,000	W. Br. Susq. R.	Hud/Susq.	0	0	0		0.00	0.23
2000	231,000	Conestoga R.	Hudson	0	0	0		0.00	0.18
2000	33,000	Swatara Cr.	Hudson	0	0	0		0.00	0.00
2000	975,000	N. Br. Susq. R.	Hudson	2	1,428	15	10	0.22	0.56

JOB VI. POPULATION ASSESSMENT OF AMERICAN SHAD IN THE UPPER CHESAPEAKE BAY

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Introduction

The American shad fishery in Maryland waters of the Chesapeake Bay was closed in 1980. Since then, the Maryland Department of Natural Resources (MDNR) has monitored adult American shad in the upper Chesapeake Bay during the spring spawning season. Besides providing an estimate of relative abundance of the adult spawning population, this mark-recapture effort also provides length, age, sex and spawning history data for this stock. The information obtained through these activities is provided to the Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC) to aid American shad restoration in the Susquehanna River.

Methods and Materials

Collection location for adult American shad in 2004 remained unchanged from 2003 (Figure 1). Hook and line captured fish were again marked with uniquely colored tags in order to differentiate between gear types, tagging locations and fish marked in previous years. All other adult data collection followed the methodology established in past years and is described in previous SRAFRC reports.

Results

Hook and line sampling in 2004 began on 26 April and ended 21 May and consisted of fourteen days of sampling. Of the 405 adult American shad angled, 402 (99%) were tagged and 37 (9%) subsequently recaptured. Recapture data for the 2004 season is summarized as follows:

Recapture Location	Number Recaptured	Total American shad Caught
East Lift	**37** - 2004 tags	109,094
West Lift	**9** - eight 2004 tags; one 2003 tag	3,426
Anglers	**3** - One 2004 tag; two 2003 tags	N/A
Commercial Gear	**1** - (Susquehanna Flats fyke net)	N/A

Since our hook and line sampling did not begin until 26 April and some American shad captured by the West lift were returned to the tailrace, only individuals collected by the East lift from April 27 through 29 May were used in the 2004 Petersen tailrace calculation. The recapture value for the Petersen statistic does not reflect fish marked prior to 2004 and subsequently recaptured or any tagged fish caught by anglers.

The 2004 adult American shad Petersen estimate for the Conowingo tailrace population was 1,005,797 (95% confidence intervals 670,531 -1,590,363; Table 1, Figure 2). This estimate was adjusted for 3% tag loss as suggested by Leggett (1976) and has been increasing exponentially since 1984 (r^2=0.72, P<0.001). American shad relative population estimates in Conowingo Dam tailrace in 2004, although the highest on record, were likely overestimated because of poor water clarity resulting in poor tag recognition and relatively high flow.

Prior to 1997, American shad captured from both fish lifts were individually handled so that all fish, both marked and unmarked, could be totaled. Beginning in 1997, the East fish lift became fully automated. Consequently, both total counts and numbers of tagged shad were recorded by two trained observers stationed at the East lift viewing chamber. This change in operating procedure at the East lift increased the chances of missing both tagged and untagged American shad and misidentifying tag colors. These errors could, therefore, affect the accuracy of the Petersen population estimates.

Catch statistics, catch-per-unit-effort (CPUE) by hook and line and the relative population estimates are presented in Table 2. Relative abundance of American shad can also be estimated and associated trends noted by examining these annual CPUE's. Measures of relative abundance for hook and line and the Conowingo fish lifts were calculated as the geometric means of fish caught per angling hour and fish caught per lift hour, respectively.

Analysis of CPUEs estimates (Figure 3) indicated the catch of adult American shad has been increasing exponentially in both gear types over time: hook and line (1984-2004) $r^2 = 0.69$, $P < 0.001$; fish lifts (1980-2004) $r^2 = 0.68$, $P<0.001$. Comparisons of the CPUE estimates to the tailrace Petersen estimates for respective years also indicated that hook and line and fish lift CPUE's were correlated with log e transformed tailrace estimates ($r^2=0.77$ $P<0.001$, $r^2=0.74$ $P=<0.001$, respectively). The increases in both hook and line and fish lift CPUE's over time and their associated positive correlations with the Petersen tailrace estimates continued in 2004 indicating that the previous upward trend in the number of American shad returning to spawn in the upper Chesapeake Bay also continued in 2004.

DNR biologists read scales from 386 of the 405 American shad collected by hook and line for age and spawning history determination. A length-at-age key was developed by determining the proportional age per 20mm lengths by sex and applying that proportion to the total number at length. For 2004, males were present in age groups 2-6 while females were found in age groups 4-7 (Table 3). The 1999 year-class of males (age V in 2004) was the most abundant age group sampled, accounting for 57% of the total catch. For females, the 1999 (V) and 1998 (VI) cohorts were the most abundant age groups, accounting for 49% and 29%, respectively, of the total catch. Age frequency modes occurred at age 5 for males and females.

The percentage of Conowingo tailrace repeat spawning American shad sampled by hook and line was 18.0% for males and 15.2% for females in 2004. The arcsine-transformed proportions of Conowingo tailrace American shad repeat spawners (sexes combined) have been increasing since 1984 (r^2=0.49, P<0.001; Figure 5).

Table 1. Relative population estimate of adult American shad in the Conowingo tailrace during spring, 2004 using the Petersen statistic.

Chapman's Modification of the Petersen estimate

$$N = \frac{(C + 1)(M + 1)}{R + 1}$$

where N = population estimate
M = number of fish tagged
C = number of fish examined for tags
R = number of tagged fish recaptured

For the 2004 survey -

C = 96,661
M = 385
R = 37

Therefore:

$$N = \frac{(96{,}661 + 1)(385 + 1)}{(37 + 1)} = 1{,}005{,}797$$

From Ricker (1975): Calculation of 95% confidence limits based on sampling error using the number of recaptures in conjunction with Poisson distribution approximation.

Using Chapman (1951):

$$N = \frac{(C + 1)(M + 1)}{(R^t + 1)}$$

where: R^t = tabular value (Ricker p343)

$$\text{Upper } N = \frac{(96{,}661 + 1)(385 + 1)}{(22.4 + 1)} = 1{,}590{,}363$$

$$\text{Lower } N = \frac{(125{,}909 + 1)(734 + 1)}{(54.5 + 1)} = 670{,}531$$

Table 2. Catch statistics, catch-per-unit- effort (CPUE) and relative population estimates for adult American shad collected by hook and line, 1984-2004.

Year	Total Hours fished	Total Catch	Catch-per unit effort	Tailrace Relative Population Estimate
1984	52.0	126	2.42	3,516
1985	85.0	182	2.14	7,876
1986	147.5	437	2.96	18,134
1987	108.8	399	3.67	21,823
1988	43.0	256	5.95	28,714
1989	42.3	276	6.52	43,650
1990	61.8	309	5.00	59,420
1991	77.0	437	5.68	84,122
1992	62.8	383	6.10	86,416
1993	47.6	264	5.55	32,529
1994	88.5	498	5.63	94,770
1995	84.5	625	7.40	210,546
1996	44.3	446	10.07	112,217
1997	58.0	607	10.47	423,324
1998	20.3	337	16.60	314,904
1999	52.0	823	15.83	583,198
2000	44.0	730	16.59	957,249
2001	65.8	972	14.77	560,912
2002	60.0	812	13.53	555,597
2003	69.3	774	11.17	487,073
2004	38.7	405	10.47	1,005,797

Table 3. Catch (N), percent repeat spawners, mean fork length and length ranges by sex and age group for adult American shad collected by hook and line during 2004.

Males					Females				
Age Group	N	Number of Repeats	Mean Length	Length Range	Age Group	N	Number of Repeats	Mean Length	Length Range
II	2	0	417	411-423	II	0	--	--	--
III	7	0	350	330-368	III	0	--	--	--
IV	39	0	392	358-421	IV	41	0	429	405-455
V	85	17	424	383-459	V	114	4	454	421-503
VI	17	10	440	408-468	VI	67	22	473	427-509
VII	0	--	--	--	VII	12	9	515	481-540
VIII	0	--	--	--	VIII	1	1	--	--
IX		--	--	--	IX	1	1	--	--

Figure 1. Location of the Conowingo Dam tailrace sampling by hook and line in 2004.

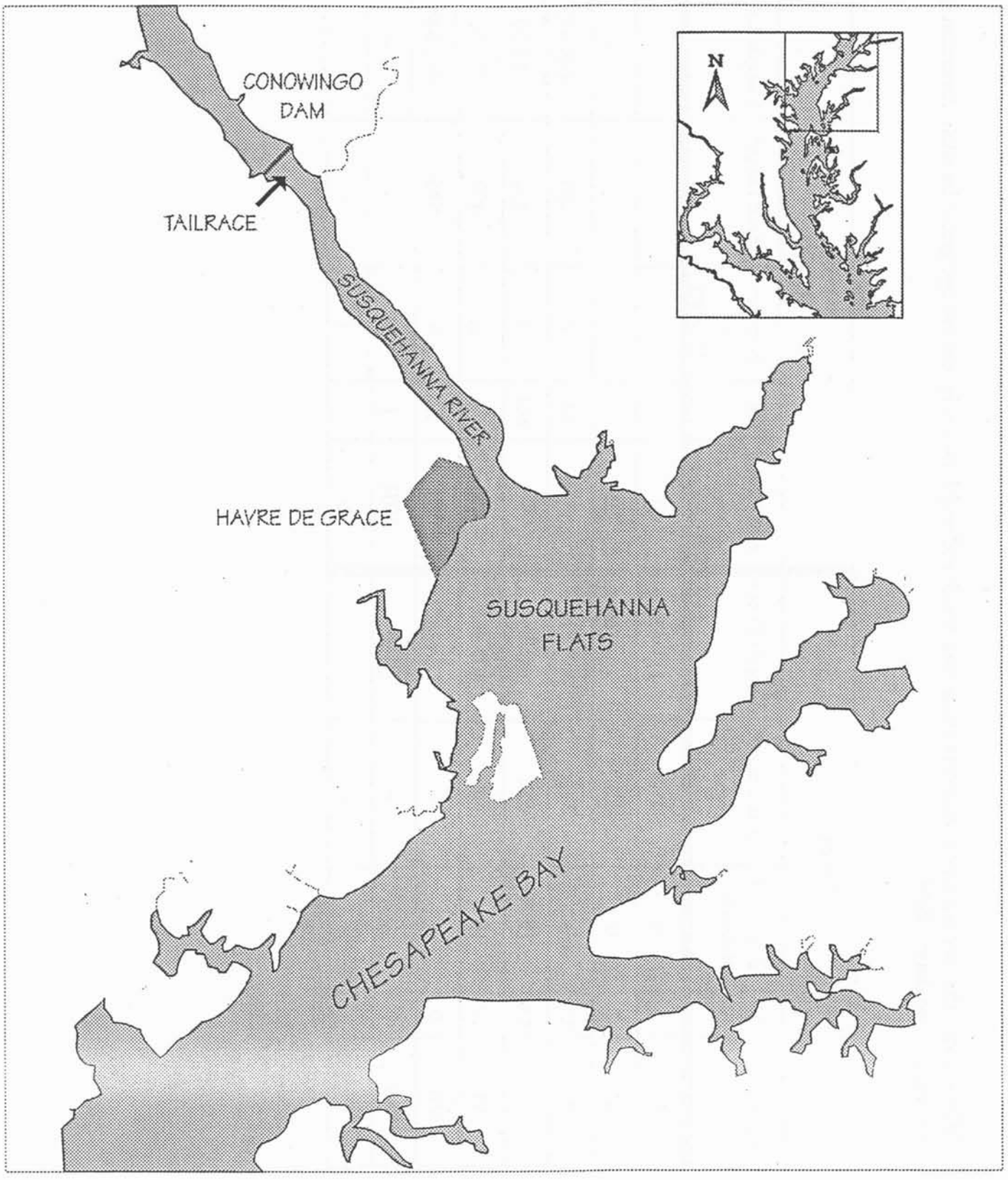


Figure 2. Conowingo Dam tailrace population estimates of American shad, 1984-2004. Bars indicate 95% confidence ranges and numbers above indicate the yearly population estimate.

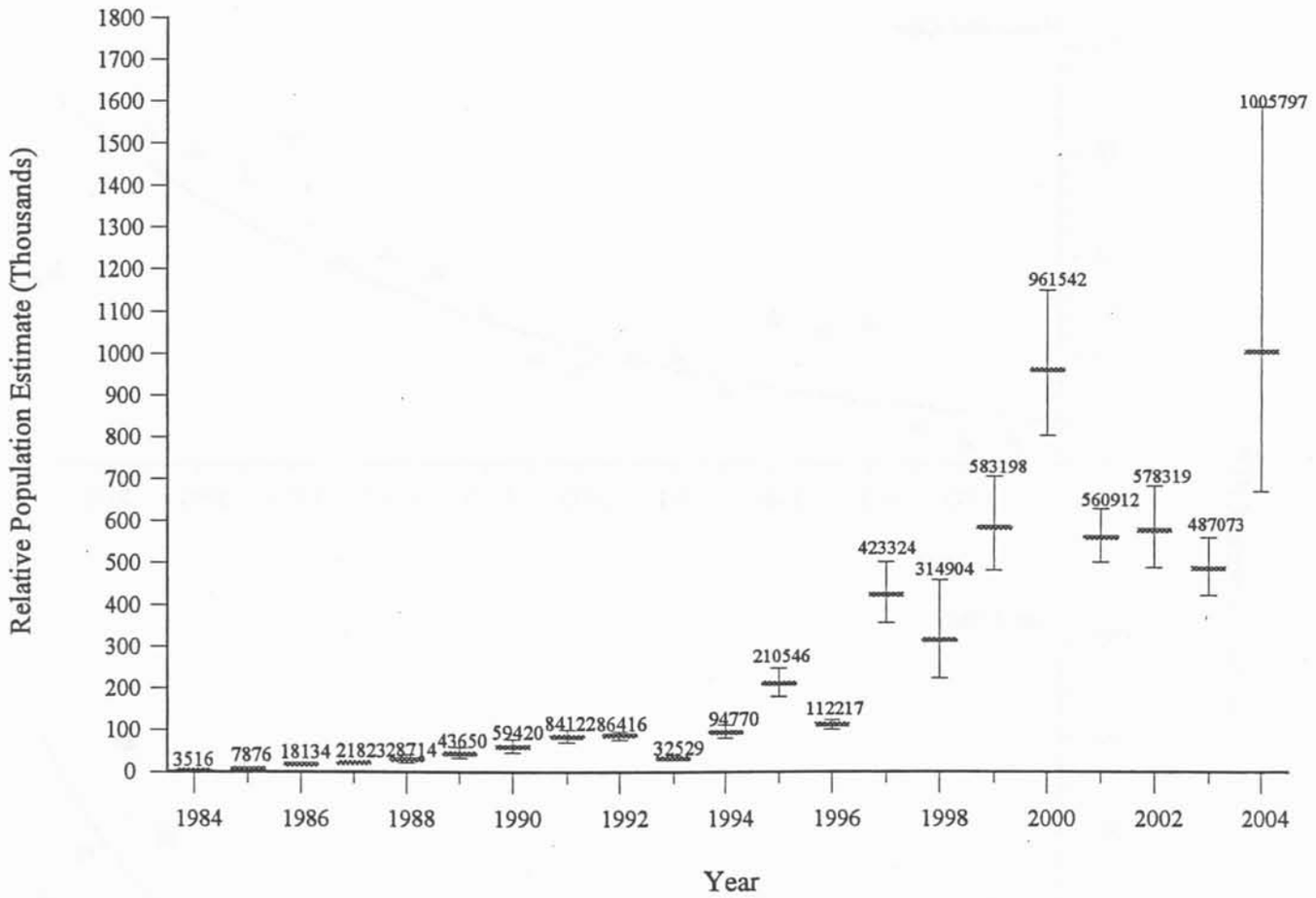


Figure 3. Regression analysis of geometric mean catch-per-unit-efforts (CPUEs) of American shad sampled by hook and line and Conowingo fish lifts, 1980-2004.

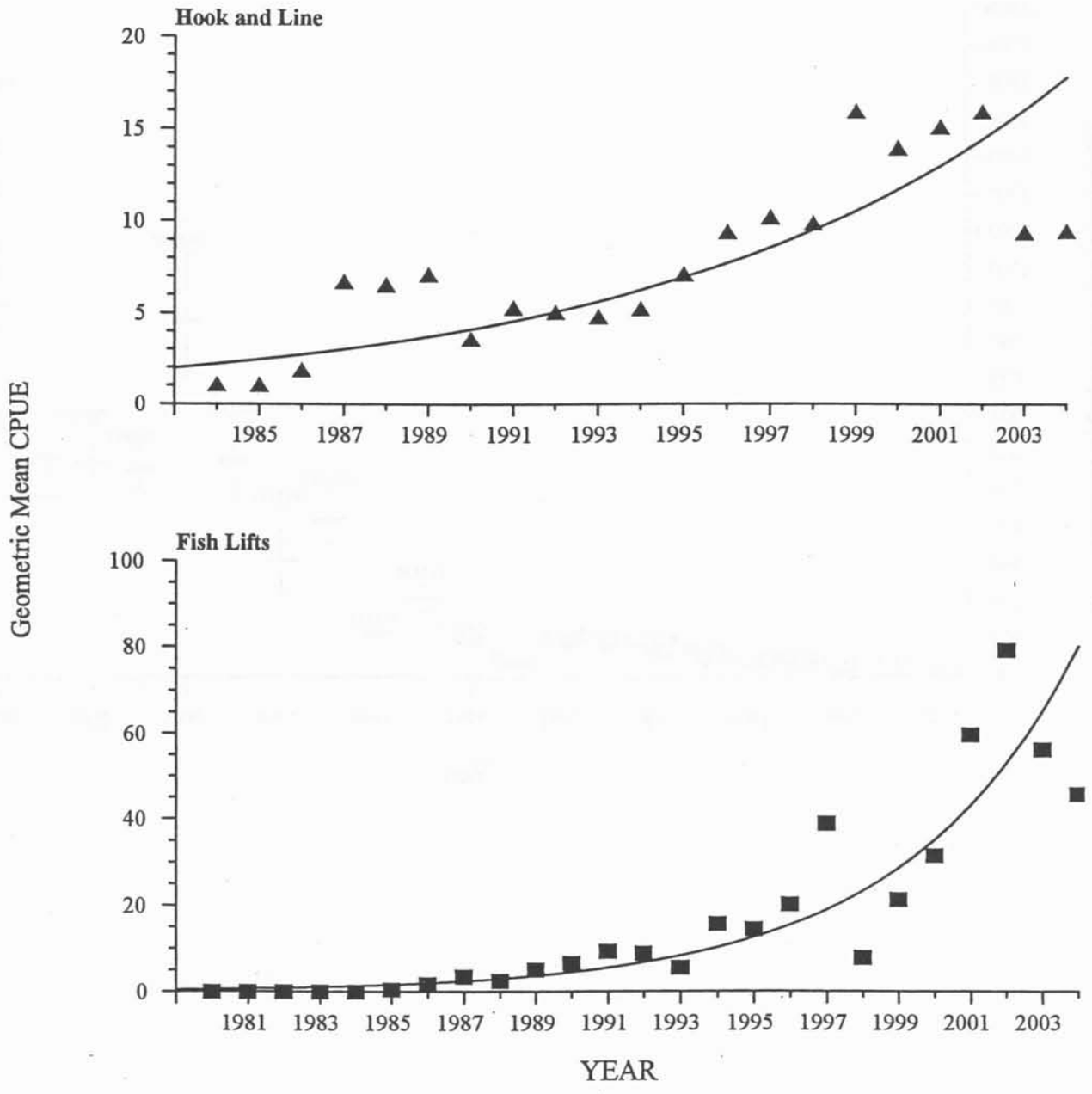
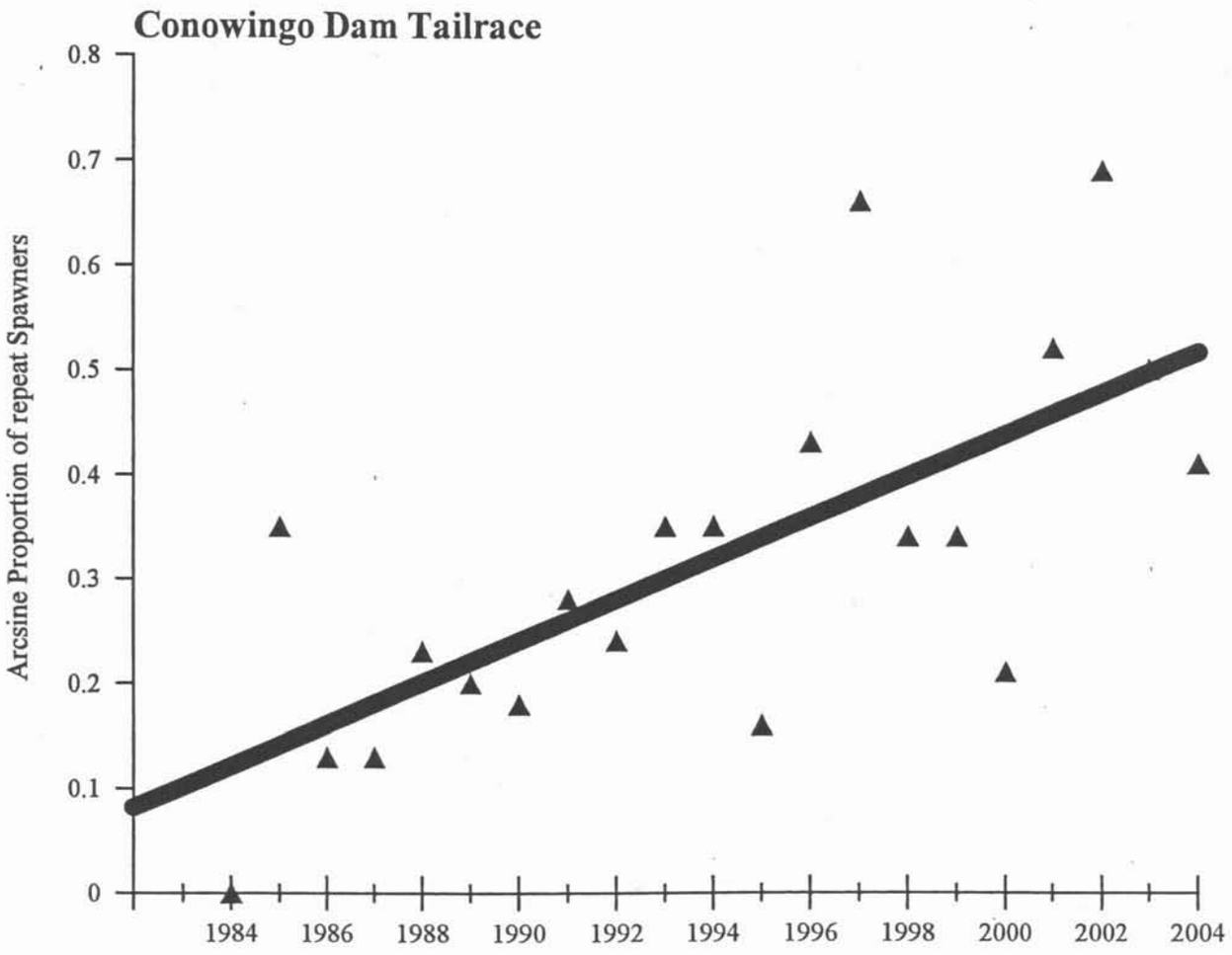


Figure 5. Trends in arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Conowingo Dam tailrace, 1984-2004.



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