JOB IV.

ABUNDANCE AND DISTRIBUTION OF JUVENILE AMERICAN SHAD IN THE SUSQUEHANNA RIVER, 2007

Abridged report for PFBC website

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SUMMARY

Juvenile American shad were collected by haul seine at Columbia, in cooling water intakes at Peach Bottom Atomic Power Station, and in strainers at Conowingo Dam. Haul seine GM CPUE (combined daily lifts) of 0.02 was the second lowest recorded for that gear type since 1990. Lift-net GM CPUE (combined daily lifts) of 0.00 was the lowest recorded for that gear type for the period of record. Lift net AUC was the lowest recorded for the period of record.

Otoliths from the four sites combined were 25% wild and 75% hatchery. Fewer eggs were delivered to the Van Dyke Hatchery, and hatchery survival was reduced, resulting in decreased production of hatchery larvae, and decreased production of juvenile American shad in the Susquehanna River basin.

INTRODUCTION

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. A total of 2,301 adult shad were collected at the Conowingo West Lift. The majority were released back into the Conowingo tailrace, with 875 retained for tank spawning. 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 2007 spring migration, Conowingo East Lift passed 25,464 American shad while fishways at Holtwood, Safe Harbor, and York Haven passed 10,338, 7,215 and 192 American shad, respectively. Some 460 blueback herring and 429 alewife were passed at Conowingo Dam. No river herring were passed at Holtwood, Safe Harbor or York Haven Dams. No hickory shad were passed at any of the four dams.

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 2007 production season, the PFBC Van Dyke Research Station for Anadromous Fish produced 1.4 million shad larvae which were released in the Susquehanna Basin in Pennsylvania. Larval releases occurred from May 22 to June 19 during a period of steadily decreasing flows. Larvae were released in the following locations and numbers:

Juniata River (Millerstown)	1,084,676
Susquehanna River (Clemson Island)	80,383
North Branch Susquehanna River (PA)	28,949
West Branch Susquehanna River	67,673
Conodoguinet Creek	68,783
West Conewago Creek	50,000

The production goal of 10 million larvae was not met, primarily due to fewer eggs shipped from the Hudson River.

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. Juvenile 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.

Geometric mean catch-per-unit effort (CPUE) was calculated as an index of juvenile abundance for haul seine and lift net collections. Ideally, CPUE would be calculated using data from individual lifts or seine hauls. Unfortunately, this data is not available prior to 1995 for lift netting and prior to 1997 for haul seining. As a result, geometric means could not be computed in the usual way for those years. Combined daily catch for each gear is available and was used as a surrogate to compute GM means. ASMFC stock assessment (ASMFC 2007) recommends use of area-under-the-curve (AUC) methods in cases where sampling is targeted at migrants moving through an area. Because the Holtwood dam lift net collects juvenile shad during the directed outmigration, (AUC) measures of juvenile abundance were also calculated for lift net collections.

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 conducted in 2007. 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 Atomic Power Station, and Conowingo Dam

Sampling at the Holtwood Dam inner fore-bay began on September 11 and continued every third day through December 7, 2007. A total of 30 sampling events was planned for 2006, but by early December it was apparent from the low collection numbers that further sampling efforts were not warranted. Therefore, the program was terminated after completion of 27 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 monitored for impinged alosines at Peach Bottom APS in 2007. Intake screen sampling was conducted daily, (Monday through Friday), from 22 October to 30 November, 2007. Twenty-seven 24-hour sampling events were conducted during the outmigration period. Conowingo Hydroelectric Station's cooling water intake strainer sampling was conducted twice weekly (Monday and Friday) from 15 October through 30 November 2007. Sampling generally occurred twice weekly during this period for a total of 13 sampling events.

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

Two juvenile American shad were captured by haul seine; both were of wild (untagged) origin. One was collected on July 24, the other on July 31 (Figure 1). The Geometric Mean Catch-Per-Unit-Effort (GM CPUE, individual haul) was 0.02 (Tables 1 and 2). Table 3 lists weekly catches of American shad by haul seine from 1989 to 2007. Catches generally peaked in August and September, except in 1989 and 1992 when catches peaked in July, and in 2005 -2007 when there was no peak.

Holtwood Dam, Peach Bottom APS, and Conowingo Dam

Lift-netting at Holtwood Dam inner fore-bay resulted in no juvenile American shad captured in 270 lifts (Table 4). Geometric Mean CPUE (individual lift) and GM CPUE (combined daily) were 0.00 (Table 5). Area under the curve (AUC) was also 0. Historical weekly catches peaked in October, except in 1985, 1997, 2000, and 2001 when catches peaked in November (Table 5, Figure 2).

Peach Bottom intake screens produced 19 juvenile American shad, one alewife and 6 blueback herring between October 23 and November 28 (Table 7).

Cooling water intake strainers at Conowingo produced 3 American shad, collected between 9 and 26 November (Tables 8 and 9). Three alewives and four blueback herring were collected in strainer samples in 2007.

Susquehanna River Mouth and Flats

In 2007, 1,122 juvenile American shad were captured at seven permanent sites and 322 juvenile American shad were captured at the auxiliary sites (Table 11).

Otolith Mark Analysis

Results of otolith analysis are presented in Table 12. A total of 24 juvenile American shad were collected in haul seines, lift nets, Peach Bottom intakes and Conowingo strainers. Of the 24 specimens evaluated for hatchery tags, 25% were wild

and 75% were hatchery. Represented in the catch were YOY shad from releases in the Juniata River, Conodoguinet Creek, West Conewago Creek, and the West Branch Susquehanna River. No shad were recaptured from releases in the North Branch Susquehanna River (see Job III, Appendix 1 for a discussion of relative survival).

DISCUSSION

River conditions for the Susquehanna River Basin during 2007 could be characterized by stable and steadily decreasing flows culminating in drought conditions in August and September. Water temperatures at Conowingo Dam increased gradually from 54F on April 23 to 80F on May 31, with the exception of a three degree drop from May 17 to May 18. No stockings were postponed due to high water.

Fish passage at Conowingo Dam continued its six –year downward trend with only 25,464 shad passed. Fish passage efficiency at Holtwood (10,338) was better than average with 41% passage, based on counts at Conowingo and Holtwood (long-term mean = 34%). Fish passage at Safe Harbor (7,215) was 70%, close to the long-term mean of 73%, based on counts at Holtwood and Safe Harbor. Fish passage at York Haven (192) was 3%, lower than the long-term mean of 12%, based on counts at Safe Harbor and York Haven. Production of wild juvenile shad was, no doubt, negatively impacted by the low numbers of shad passed into spawning habitat above York Haven Dam.

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. In 2007, haul seine and lift net CPUE were among lowest ever recorded.

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. GM CPUE

for lift net collections (Table 5) in the Holtwood Dam forebay was 0.00, an all-time low, matching 2004. Juvenile shad abundance has been below normal for six consecutive years, a disturbing trend that may impact upstream fish passage counts during 2008 to 2012. In 2002, problems at the Van Dyke Hatchery resulted in release of comparatively few healthy larvae. In 2003 and 2004, high river flows had a negative impact on survival of stocked hatchery larvae and on fish passage efficiency. Poor catch rates for juvenile shad in 2005 may have been due, in part, to fewer larvae stocked. In 2006, poor catch rates were attributed to fewer larvae stocked (compared to the decade of the 1990's) and the late June flood which, undoubtedly, impacted survival. In 2007, flows were low and decreased steadily during the entire season. The poor catch rates in 2007 can be attributed to decreased egg deliveries, poor survival in the hatchery (see Job III), and poor fish passage.

Stock Composition and Mark Analysis

Hatchery contribution was 75% for all sites combined and exceeded wild contribution at nearly every collection site in 2007. Contribution of hatchery fish from Columbia, Peach Bottom and Conowingo was 0%, 89% and 50%, respectively.

ACKNOWLEDGMENTS

Normandeau Associates (Drumore, PA) was contracted by the PFBC to perform juvenile collections. Many individuals supplied information for this report. Keith Beamer and Alinson Antony processed shad otoliths.

LITERATURE CITED

ASMFC 2007. American Shad Stock Assessment Report for Peer Review. Volume I. Stock Assessment Report No. 07-01 (Supplement) of the Atlantic States Marine Fisheries Commission. Atlantic States Marine Fisheries Commission, Bethesda, MD.

Figure 1. Number of American shad collected by haul seine and river flow, Susquehanna River, 2007.

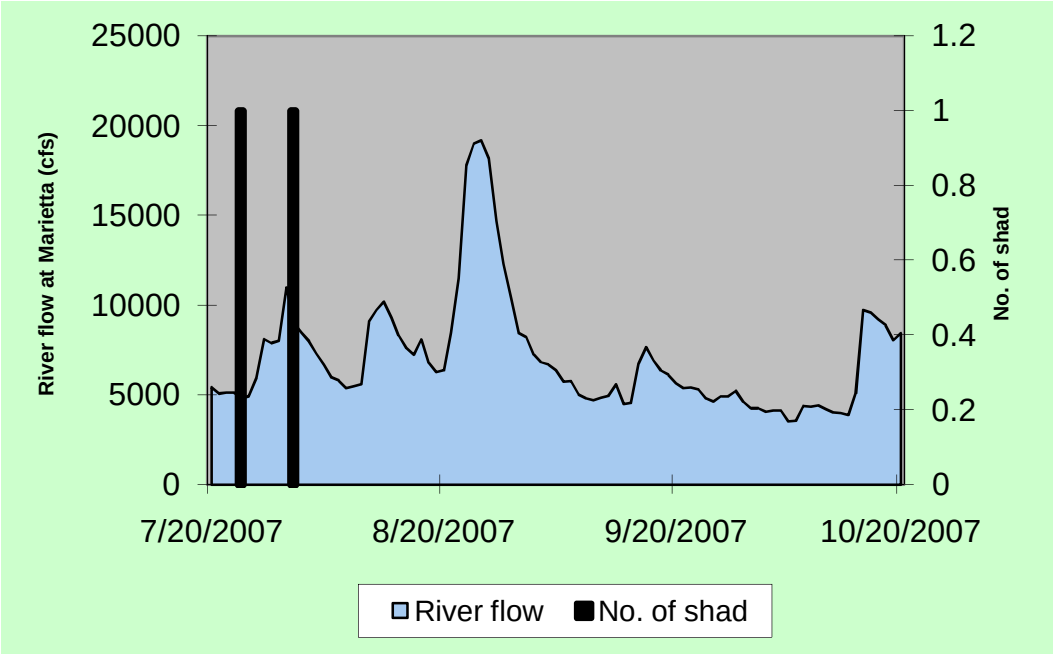

Figure 2. Annual YOY American shad CPUE for lift net collections at the Holtwood Dam forebay

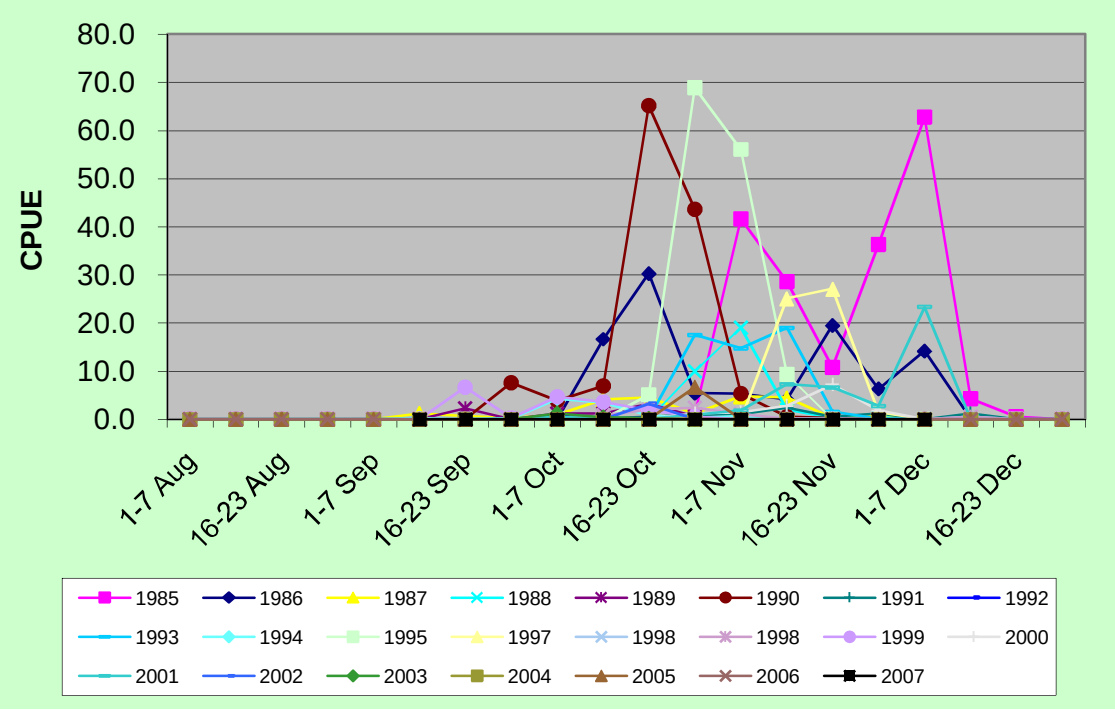

Table 1. Number of fish collected by haul seine from the lower Susquehanna River near Columbia, Pennsylvania in 2007.

Date	18-Jul	24-Jul	31-Jul	7-Aug	14-Aug	21-Aug	28-Aug	5-Sep	12-Sep	18-Sep	25-Sep	3-Oct	10-Oct	16-Oct	23-Oct	Total
Daily Mean River Flow (cfs)	5,270	4,750	8,900	5,150	8,080	9,940	11,500	6,020	5,130	6,400	4,470	4,130	4,250	9,140	9,570	
Water Temperature (°C)	28.0	24.0	28.0	29.5	27.0	19.0	25.5	22.0	23.0	20.0	23.5	22.0	23.5	16.0	18.0	
Secchi Disk (in)	48	72	36	43	25	34	64	90	87	84	88	85	98	90	60	
American shad	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	2
Gizzard shad	196	30	5	41	48	101	245	5	9	47	-	1	-	10	34	772
Common carp	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	2
Golden shiner	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Comely shiner	3	3	-	2	6	3	-	1	-	1	-	-	-	-	2	21
Spottail shiner	-	-	2	-	1	-	6	-	-	-	-	1	-	-	-	10
Spotfin shiner	56	15	27	24	13	17	9	14	5	8	19	9	19	17	-	252
Mimic shiner	-	2	-	3	5	-	-	-	1	-	-	1	1	-	-	13
Bluntnose minnow	-	-	-	-	1	-	-	-	-	-	3	-	-	-	-	4
Fallfish	-	3	-	-	2	1	-	-	-	1	-	-	-	-	-	7
Quillback	20	4	2	-	1	1	4	-	10	-	-	-	7	-	3	52
Northern hog sucker	-	-	-	2	-	-	1	-	-	-	-	-	1	-	-	4
Channel catfish	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	2
Banded killifish	-	-	-	1	1	-	3	-	-	-	-	-	-	-	-	5
Mosquitofish	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	5
Rock bass	-	1	-	-	-	1	1	1	1	1	-	-	-	1	1	8
Redbreast sunfish	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Pumpkinseed	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	5
Bluegill	-	-	-	-	-	-	-	2	4	2	13	-	3	3	3	30
Smallmouth bass	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2
Tessellated darter	-	-	2	-	1	3	-	-	-	-	-	1	-	-	-	7
Walleye	-	-	1	1	-	-	7	-	-	-	1	-	2	-	-	12
Total	**275**	**60**	**41**	**74**	**79**	**127**	**277**	**23**	**30**	**62**	**46**	**13**	**35**	**31**	**44**	**1,217**
No. of Species	**4**	**9**	**8**	**7**	**10**	**7**	**9**	**5**	**6**	**8**	**6**	**5**	**7**	**4**	**6**	**22**

Table 2. Index of abundance for juvenile American shad collected by haul seine at Marietta, Columbia and Wrightsville, 1990 - 2007.

		Total				Wild			Hatchery		
Year	No. Hauls	No. Fish	Mean Combined Daily CPUE	GM Combined Daily CPUE	GM Individual Haul CPUE*	No. Fish	Mean Combined Daily CPUE (Wild)	GM Combined Daily CPUE (Wild)	No. Fish	Mean Combined Daily CPUE (Hatchery)	GM Combined Daily CPUE (Hatchery)
1990	87	285	4.40	1.23	-	13	0.15	0.11	272	3.13	1.18
1991	144	170	1.01	0.54	-	80	0.48	0.35	90	0.63	0.21
1992	97	348	5.10	1.69	-	166	2.57	0.90	182	1.88	0.94
1993	111	235	1.99	1.27	-	174	1.61	1.01	61	0.55	0.28
1994	110	395	4.85	2.30	-	254	3.07	1.31	141	1.29	1.16
1995	48	409	8.92	7.89	-	58	1.29	1.06	351	7.30	6.85
1996	105	283	2.89	2.05	-	157	1.61	1.20	126	1.20	0.99
1997	90	879	9.77	6.77	3.36	136	1.51	1.24	743	8.26	5.65
1998	94	230	2.51	1.03	0.50	5	0.05	0.05	225	2.39	0.97
1999	90	322	3.58	1.16	0.67	13	0.15	0.13	309	3.43	1.06
2000	90	31	0.34	0.26	0.14	0	0.00	0.00	31	0.34	0.26
2001	90	377	4.19	3.04	1.52	119	1.32	1.25	258	2.87	2.14
2002	84	0	0.00	0.00	0.00	0	0.00	0.00	0	0.00	0.00
2003	48	17	0.35	0.28	0.20	2	0.04	0.04	15	0.31	0.25
2004	66	25	0.38	0.25	0.17	0	0.00	0.00	25	0.38	0.25
2005	90	23	0.26	0.24	0.16	21	0.23	0.24	2	0.02	0.02
2006	66	1	0.02	0.01	0.01	0	0.00	0.00	1	0.02	0.01
2007	66	2	0.02	0.02	0.02	2	0.02	0.02	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 through 2007.

Month	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
1-7 Jul	-	-	-	0	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2
8-15 Jul	1,048	-	0	120	0	27	-	2	44	-	0	7	-	-	-	0	-	-	-	1,248
16-23 Jul	-	-	0	6	-	70	53	18	28	24	0	3	46	0	0	0	2	*	0	250
24-31 Jul	45	31	-	-	0	60	24	15	22	144	1	0	42	0	0	*	0	*	2	386
1-7 Aug	-	0	0	20	0	24	29	32	14	30	1	2	70	0	*	*	5	0	0	227
8-15 Aug	61	0	0	2	8	13	35	56	20	0	0	6	37	0	*	0	1	0	0	239
16-23 Aug	7	69	0	16	0	46	40	43	171	9	0	1	36	0	0	*	2	0	0	440
24-31 Aug	-	-	-	-	13	-	42	39	120	10	10	0	36	0	8	16	2	0	0	296
1-7 Sep	-	25	12	-	20	-	43	34	129	3	*	0	23	0	5	5	3	*	0	302
8-15 Sep	-	97	16	-	41	75	65	4	135	3	264	0	31	0	4	4	0	0	0	739
16-23 Sep	-	28	30	-	27	14	46	12	59	4	17	0	15	0	0	*	1	0	0	253
24-30 Sep	-	0	73	-	11	5	15	15	32	0	20	1	34	0	*	*	2	0	0	208
1-7 Oct	-	0	69	2	22	5	19	10	91	3	1	0	6	0	*	0	0	0	0	228
8-15 Oct	-	0	7	-	0	2	31	3	0	0	3	11	1	0	0	0	2	0	0	60
16-23 Oct	-	-	5	-	-	10	-	-	14	0	5	0	0	*	*	0	3	1	0	38
24-31 Oct	-	-	0	0	-	-	0	0	-	-	-	-	0	0	*	0	*	-	-	0
1-7 Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	0
8-15 Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	0
TOTAL	**1,161**	**250**	**212**	**166**	**142**	**353**	**442**	**283**	**879**	**230**	**322**	**31**	**377**	**0**	**17**	**25**	**23**	**1**	**2**	**4,916**

* No sampling due to high river flow.

Table 4. Number and percent composition of fishes collected by an 8 x 8 ft lift net from Holtwood Power Station inner forebay, 2007.

Date:	11 Sep	14 Sep	17 Sep	20 Sep	23 Sep	26 Sep	29 Sep	02 Oct	05 Oct	08 Oct	11 Oct	14 Oct	17 Oct	20 Oct	23 Oct	26 Oct
Water Temp (°C):	26.0	25.0	23.5	22.5	22.0	22.5	22.5	22.0	22.5	22.5	22.0	21.0	19.3	17.0	18.8	17.5
Secchi (in):	48	33	75	52	54	50	53	38	42	40	35	50	48	46	43	40
River Flow (cfs):	6,260	4,520	6,740	5,450	5,130	4,480	4,660	4,100	2,980	4,380	3,870	6,170	9,250	8,620	9,580	15,400
Start Time (hr):	1848	1829	1845	1851	1845	1815	1823	1820	1800	1800	1804	1800	1800	1751	1750	1732
End Time (hr):	2013	2002	2000	2002	2000	1940	1930	1940	1940	1940	1855	1935	1915	1914	1909	1913
Gizzard shad	1	252	100	1	-	-	-	-	-	5	5	2	34	21	11	7
Comely shiner	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Spottail shiner	-	8	6	-	-	-	-	1	-	-	-	-	-	-	-	-
Spotfin shiner	1	3	-	-	1	1	-	8	-	-	-	-	1	-	-	-
Mimic shiner	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bluegill	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Total	**2**	**266**	**109**	**2**	**1**	**1**	**0**	**9**	**0**	**5**	**5**	**2**	**35**	**21**	**11**	**7**
No. of Species	**2**	**5**	**3**	**2**	**1**	**1**	**0**	**2**	**0**	**1**	**1**	**1**	**2**	**1**	**1**	**1**

Date:	29 Oct	01 Nov	04 Nov	07 Nov	10 Nov	13 Nov	16 Nov	19 Nov	21 Nov	25 Nov	28 Nov	01 Dec	04 Dec	07 Dec		
Water Temp (°C):	15.5	13.5	12.5	10.5	9.5	9.5	8.5	6.8	6.5	6.8	6.5	5.0	3.0	1.0		
Secchi (in):	30	36	47	44	55	69	47	43	40	60	48	30	20	40		
River Flow (cfs):	27,400	24,100	14,800	11,300	10,200	11,100	21,000	41,600	33,800	34,900	41,900	57,800	35,700	36,100		
Start Time (hr):	1742	1710	1634	1620	1600	1605	1611	1607	1632	1556	1555	1603	1604	1606		
End Time (hr):	1848	1849	1818	1738	1755	1737	1740	1722	1754	1715	1726	1715	1720	1716	**TOTAL**	**%**
Gizzard shad	12	63	173	-	30	687	8	3	28	-	4	1	1	-	1,449	97.4
Comely shiner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	0.3
Spottail shiner	-	1	-	-	-	-	-	-	-	-	-	-	-	-	16	1.1
Spotfin shiner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	1.0
Mimic shiner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1
Bluegill	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2	0.1
Total	**12**	**64**	**173**	**0**	**31**	**687**	**8**	**3**	**28**	**0**	**4**	**1**	**1**	**0**	**1,488**	**100.0**
No. of Species	**1**	**2**	**1**	**0**	**2**	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**6**	

Table 5. Index of abundance for juvenile American shad collected by lift net in the forebay of Holtwood Hydroelectric Station, 1985-2006.

		Total					Wild				Hatchery			
Year	No. Lifts	No. Fish	Mean Combined Daily CPUE	GM Combined Daily CPUE	GM Individual Lift CPUE*	Area under curve AUC	No. Fish	Mean Combined Daily CPUE	GM Combined Daily CPUE	Area under curve AUC	No. Hatchery Fish	Mean Combined Daily CPUE	GM Combined Daily CPUE	Area under curve AUC
1985	378	3,626	20.3	7.5		1423								
1986	404	2,926	10.3	5.7		917								
1987	428	832	3.2	1.9		182								
1988	230	929	3.9	1.3		255								
1989	396	556	0.5	0.3		60								
1990	300	3,988	13.3	3.4		1060	70	0.2	0.2	17	3,918	13.1	3.6	1043
1991	290	208	0.7	0.5		72	19	0.1	0.1	7	189	0.7	0.5	66
1992	300	39	0.1	0.1		14	14	0.0	0.0	5	25	0.1	0.1	9
1993	300	1,095	3.7	1.3		383	669	2.8	0.6	234	426	1.4	0.6	149
1994	300	206	0.7	0.4		71	35	0.1	0.1	12	171	0.6	0.3	59
1995	115	1,048	9.1	1.3		802	83	0.7	0.3	59	965	8.4	1.2	744
1997	300	1,372	4.6	0.9	0.6	412	100	0.3	0.2	30	1,272	4.2	0.9	382
1998	300	180	0.6	0.4	0.2	53	9	0.0	0.0	3	171	0.6	0.4	50
1999	300	490	1.6	0.8	0.5	147	19	0.1	0.1	6	471	1.6	0.8	141
2000	300	406	1.4	0.6	0.2	122	4	0.0	0.0	1	402	1.3	0.6	121
2001	299	1,245	4.2	1.4	0.4	322	538	1.8	0.4	135	707	2.4	1.0	186
2002	300	68	0.2	0.1	0.1	20	15	0.1	0.0	5	53	0.2	0.1	16
2003	300	61	0.2	0.1	0.1	18	3	0.0	0.0	1	58	0.2	0.1	17
2004	240	0	0.0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0
2005	300	200	0.7	0.1	0.1	60	47	0.2	0.1	14	153	0.5	0.1	46
2006	230	8	0.0	0.03	0.01	2	0	0.0	0.0	0	8	0.0	0.0	2
2007	300	0	0.0	0.00	0.00	0	0	0.0	0.0	0	0	0.0	0.0	0

* Required by ASMFC

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

Note: Collections were cut short in some years when it was clear that the outmigration was over.
Simultated lifts were recorded to ensure comparable CPUE.

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*.

	Year																						
Week	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**Mean**
1-7 Aug	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
8-15 Aug	-	-	-	-	-	-	0.0	-	-	-	0.0	-	-	-	-	-	-	-	-	-	-		0.0
16-23 Aug	-	-	-	-	-	0.0	0.0	0.0	-	-	0.0	-	-	-	-	-	-	-	-	-	-		0.0
24-31 Aug	-	-	-	-	-	0.0	0.0	0.0	-	-	0.0	-	-	-	-	-	-	-	-	-	-		0.0
1-7 Sep	-	-	-	0.0	-	0.0	0.0	0.0	0.0	-	0.0	-	-	-	-	-	-	-	-	-	-		0.0
8-15 Sep	-	-	1.3	-	-	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	-	-	0.0	0.0	0.0	0.00	0.1
16-23 Sep	-	-	0.7	-	2.3	0.0	0.0	0.1	0.0	0.0	-	0.0	0.0	6.7	0.0	0.0	-	0.0	0.0	0.0	0.0	0.00	0.6
24-30 Sep	-	-	0.3	-	-	7.6	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.5
1-7 Oct	-	-	0.9	0.0	1.2	3.9	0.1	0.9	0.2	4.3	0.1	0.0	0.1	4.7	0.0	0.5	0.0	1.3	0.0	0.0	0.0	0.00	0.9
8-15 Oct	-	16.7	4.1	0.1	1.2	6.9	0.1	0.0	0.2	3.6	0.0	0.0	0.8	3.7	0.0	0.1	0.0	0.5	0.0	0.0	0.0	0.00	1.8
16-23 Oct	0.1	30.3	4.5	0.0	3.2	65.1	0.6	0.5	0.1	0.8	5.1	0.0	2.1	1.9	0.2	0.1	3.3	0.3	0.0	0.0	0.0	0.00	5.4
24-31 Oct	1.0	5.4	1.3	10.0	0.5	43.6	0.9	0.5	17.5	0.2	68.9	0.2	2.5	0.5	1.2	0.9	0.0	0.0	0.0	6.7	0.2	0.00	7.4
1-7 Nov	41.6	5.3	4.8	19.1	0.0	5.3	1.1	0.0	14.8	0.7	56.1	0.0	1.1	0.0	1.5	1.9	0.0	0.0	0.0	0.0	0.0	0.00	7.0
8-15 Nov	28.6	4.1	4.5	2.0	0.0	0.5	2.4	0.0	19.0	0.1	9.3	25.1	0.1	0.0	2.8	7.3	0.0	0.0	0.0	0.0	0.0	0.00	4.8
16-23 Nov	10.8	19.5	0.3	0.3	0.0	0.2	0.5	0.0	1.6	0.0	0.0	27.1	0.1	0.0	7.2	6.7	0.0	0.0	0.0	0.0	-	0.00	3.5
24-30 Nov	36.4	6.3	0.7	0.4	-	0.0	1.2	-	0.1	0.0	0.0	1.5	0.1	0.0	1.9	2.8	0.0	0.0	0.0	0.0	-	0.00	2.7
1-7 Dec	62.8	14.2	0.0	0.0	-	-	-	-	-	0.0	-	0.0	0.0	0.0	0.0	23.4	0.0	0.0	0.0	-	-	0.00	7.2
8-15 Dec	4.3	0.1	-	-	-	-	1.2	-	-	-	-	-	0.6	0.0	0.0	-	0.0	0.0	-	-	-		0.8
16-23 Dec	0.5	0.0	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-		0.2
24-31 Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
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	200	8	0	
Total lifts	378	404	428	230	286	290	370	240	240	250	230	300	300	300	300	300	260	300	240	270	230	300	
CPUE	9.59	7.24	1.94	4.04	1.94	13.75	0.56	0.16	4.56	0.82	9.13	4.57	0.60	1.63	1.35	4.15	0.26	0.20	0.00	0.74	0.03	0.00	

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

Table 7. Number of fish collected during intake screen sampling by unit at Peach Bottom Atomic Power Station in fall, 2007.

Species	Unit 2	Unit 3	Total
Alewife	1	0	**1**
Blueback herring	5	1	**6**
American shad	9	11	**20**
Gizzard shad	70,819	79,497	**150,316**
Carp	1	1	**2**
Golden shiner	1	1	**2**
Comely shiner	2	4	**6**
Spottail shiner	1	1	**2**
Spotfin shiner	1	2	**3**
Quillback	2	1	**3**
Northern hogsucker	1	1	**2**
White catfish	0	1	**1**
Channel catfish	134	143	**277**
Flathead catfish	1	1	**2**
Rock bass	8	11	**19**
Green sunfish	9	12	**21**
Pumpkinseed	0	3	**3**
Bluegill	505	671	**1,176**
Smallmouth bass	3	1	**4**
Largemouth bass	1	2	**3**
White crappie	7	15	**22**
Black crappie	0	2	**2**
Yellow perch	0	1	**1**
Walleye	66	95	**161**
Tessellated darter	6	2	**8**
Greenside darter	1	0	**1**
Logperch	0	1	**1**
Crayfish	74	152	**226**
TOTAL	***71,658***	***80,633***	***152,291***

Table 8. Number of juvenile American shad collected during intake screen sampling by unit at Peach Bottom Atomic power Station in fall, 2007.

Date	Unit 2	Unit 3	Total
23 Oct	1 (Adult)	0	**0**
29 Oct	0	1	**1**
02 Nov	0	1	**1**
13 Nov	0	1	**1**
19 Nov	2	0	**2**
20 Nov	2	4	**6**
21 Nov	2	3	**5**
27 Nov	2	0	**2**
28 Nov	0	1	**1**
TOTAL	***8***	***11***	***19***

Table 9. Species and number of fish collected during cooling water intake sampling at Conowingo Dam in Fall, 2007.

Species	Francis Units (7)	Kaplan Units (4)	Total
American shad	3	0	3
Gizzard shad	10,886	30,077	40,963
Alewife	3	0	3
Blueback herring	3	1	4
Comely shiner	2	3	5
Channel catfish	4	1	5
Carp	3	0	3
White perch	1	0	1
Largemouth bass	1	0	1
White crappie	1	0	1
TOTAL	**10,907**	**30,082**	**40,989**

Table 10. Number of juvenile American shad collected during cooling water intake strainer sampling at Conowingo Dam in fall, 2007.

Date	Francis Units (7)	Kaplan Units (4)	Total
09 Nov	1	0	**1**
26 Nov	2	0	**2**
TOTAL	***3***	***0***	***3***

Table 11. Catch of juvenile American shad by location from the upper Chesapeake Bay during the 2007 Maryland DNR juvenile finfish haul seine survey.

Permanent Sites

Location	Round 1	Round 2	Round 3	Totals
HOWELL PT.	4	24	8	36
TIMS CR	1	0	0	1
SASSAFRAS NRMA	17	15	2	34
PARLOR PT.	8	9	4	21
ELK NECK PARK	0	133	32	165
WELCH PT.	126	133	14	273
HYLAND PT.	254	194	144	592
Total	410	508	204	1122
Mean Catch Per Haul	**102.50**	**127.00**	**51.00**	

Auxiliary Sites

Location	Round 1	Round 2	Round 3	Totals
CARPENTER PT	25	8	2	35
POPLAR PT	no haul	no haul	no haul	
PLUM PT	37	71	140	248
SPOIL ISLAND	10	13	14	37
TYDINGS ESTATE	2	0	0	2
TOLCHESTER	0	0	0	0
Total	74	92	156	322
Mean	**14.80**	**18.40**	**31.20**	

Table 12. Analysis of juvenile American shad otoliths collected in the Susquehanna River, 2007

		Immersion marks											
Collection Site	Coll. Date	Day 15, 18 Jun. R./ Susq. R.	Days 3,6,9,15 N. Br. Susq. R.(PA)	Days 3,6,9, 12,15 W. Br. Susq. R.	Days 3,9,12 15,18 W. Cone wago	Days 3,6,12,15 Conodo guinet Cr.	Total Hatchery		Total Wild		Total Processed	Total Collected
Columbia	7/24/07	0.0	0.0	0.0	0.0	0.0	0.0		1.0		1	1
	7/31/07	0.0	0.0	0.0	0.0	0.0	0.0		1.0		1	1
Peach Bottom	11/2/07	1.0	0.0	0.0	0.0	0.0	1.0		0.0		1	1
Impingement	11/13/07	0.0	0.0	0.0	1.0	0.0	1.0		0.0		1	1
	11/19/07	2.0	0.0	0.0	0.0	0.0	2.0		0.0		2	2
	11/20/07	6.0	0.0	1.0	0.0	0.0	7.0		0.0		7	7
	11/21/07	4.0	0.0	0.0	0.0	0.0	4.0		1.0		5	5
	11/27/07	1.0	0.0	0.0	0.0	1.0	2.0		0.0		2	2
	11/29/07	0.0	0.0	0.0	0.0	0.0	0.0		1.0		1	1
Conowingo	11/8/07	0.0	0.0	0.0	0.0	0.0	0.0		1.0		1	1
Strainers	11/25/07	1.0	0.0	0.0	0.0	0.0	1.0		1.0		2	2
Holt./P. Bot./Con.		15.0	0.0	1.0	1.0	1.0	18.0	**	4.0	**	22.0	22.0
Percent		68.2%	0.0%	4.5%	4.5%	4.5%	81.8%		18.2%			
Grand Total		15.0	0.0	1.0	1.0	1.0	18.0	**	6.0	**	24.0	24.0
Percent		62.5%	0.0%	4.2%	4.2%	4.2%	75.0%		25.0%			

**When the entire sample collected was not processed, the shad successfully processed were weighted to ensure that row totals equalled the total number collected.

Note: Two fish had tags only on day 15. These were identified as 15, 18d tags based on tag retention studies. One fish had a tag on days 3,6,9 and 12. This fish was identified as tagged on days 3,6,9,12 and 15, based on tag retention studies (see Tag retention section of Job IV).