JOB IV.

ABUNDANCE AND DISTRIBUTION OF JUVENILE AMERICAN SHAD IN THE SUSQUEHANNA RIVER, 2008

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INTRODUCTION

This report summarizes the results of bio-monitoring activities for juvenile alosines conducted in the Susquehanna River and its tributaries in 2008.

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 2,627adult shad were collected at the Conowingo West Lift. The majority were released back into the Conowingo tailrace, with 1007 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 2008 spring migration, Conowingo East Lift passed 19,914 American shad while fishways at Holtwood, Safe Harbor, and York Haven passed 2,795, 1,252 and 21 American shad, respectively. One blueback herring and one 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 2008 production season, the PFBC Van Dyke Research Station for Anadromous Fish produced 2.5 million shad larvae which were released in the Susquehanna Basin in Pennsylvania. Larval releases occurred from May 28 to June 19 during a period of steadily decreasing flows. Larvae were released in the following locations and numbers:

Juniata River (Millerstown)	48,421
Susquehanna River (Clemson Island)	175,000
North Branch Susquehanna River (PA)	172,581
West Branch Susquehanna River	1,733,314
Conodoguinet Creek	75,699
West Conewago Creek	45,507
Conestoga River	115,529
Swatara Creek	124,031

The production goal of 10 million larvae was not met, primarily due to the loss of the Hudson River as an egg source.

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 2008. 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 16 and continued every third day through December 12, 2008, for a total of 30 sampling 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 2008. Intake screen sampling was conducted daily, (Monday through Friday), from 27 October to 12 December, 2008. Twenty 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 20 October through 5 December 2008. Sampling occurred twice weekly during this period for a total of 14 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

No juvenile American shad were captured by haul seine. The Geometric Mean Catch-Per-Unit-Effort (GM CPUE, individual haul) was 0.00 (Tables 1 and 2). Table 3 lists weekly catches of American shad by haul seine from 1989 to 2008. Catches generally peaked in August and September, except in 1989 and 1992 when catches peaked in July, and in 2005 -2008 when there was no peak.

Holtwood Dam, Peach Bottom APS, and Conowingo Dam

Lift-netting at Holtwood Dam inner fore-bay resulted in one juvenile American shad captured in 300 lifts (Table 4). Geometric Mean CPUE (individual lift) and GM CPUE (combined daily) were 0.002 and 0.004, respectively (Table 5). Area under the curve (AUC) was also 0.2. Historical weekly catches peaked in October, except in 1985, 1997, 2000, and 2001 when catches peaked in November (Table 6).

Peach Bottom intake screens produced 46 juvenile American shad, 13 alewife and no blueback herring between November 3 and December 10 (Table 7).

Cooling water intake strainers at Conowingo produced 1 American shad, collected on 10 November (Tables 8 and 9). Two alewives and no blueback herring were collected in strainer samples in 2008.

Susquehanna River Mouth and Flats

In 2008, 2 juvenile American shad were captured at seven permanent sites and no 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 48 juvenile American shad were collected in haul seines, lift nets, Peach Bottom intakes and Conowingo strainers. Of the 47 specimens evaluated for hatchery tags, 2% were wild and 98%

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

DISCUSSION

River conditions for the Susquehanna River Basin during 2008 could be characterized by stable and steadily decreasing flows culminating in drought conditions in August and September. Water temperatures at Conowingo Dam fluctuated between 57F and 66F during April 17 to May 23 and then increased steadily thereafter. Stocking of 15 tanks was delayed due to high water in the Juniata River. Most of these were later stocked in the West Branch where river conditions were more favorable.

Fish passage at Conowingo Dam continued its six –year downward trend with only 19,914 shad passed. Fish passage efficiency at Holtwood (2,795) was worse than average with 14% passage, based on counts at Conowingo and Holtwood (long-term mean = 32%). Fish passage at Safe Harbor (1,252) was 45%, significantly lower than the long-term mean of 71%, based on counts at Holtwood and Safe Harbor. Fish passage at York Haven (21) was 2%, lower than the long-term mean of 11%, 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.

<u>Abundance – Main Stem</u>

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 2008, 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 0.00, the lowest value ever recorded for that gear type. GM CPUE for lift net collections (Table 5) in the Holtwood Dam forebay was 0.004, based on collection of a single juvenile shad. Juvenile shad abundance has been below normal for six consecutive years (Figure 2), a disturbing trend that will impact upstream fish passage counts during 2008 to 2013. 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. Poor catch rates in 2007 were attributed to decreased egg deliveries, poor survival in the hatchery (see Job III), and poor fish passage. The poor catch rate in 2008 was likely due to decreased egg deliveries and poor fish passage.

Stock Composition and Mark Analysis

Hatchery contribution was 98% for all sites combined with only one wild juvenile shad collected. The one wild juvenile shad was collected at Peach Bottom on December 5.

SUMMARY

- Juvenile American shad were collected by lift net at Holtwood Dam, in cooling water intakes at Peach Bottom Atomic Power Station, and in strainers at Conowingo Dam.
- Haul seine GM CPUE (combined daily lifts) of 0.00 was the lowest recorded for that gear type since 1990.
- Lift-net GM CPUE (combined daily lifts) of 0.004 was the third lowest recorded

for that gear type for the period of record. Lift net AUC (0.002) was the third lowest recorded for the period of record.

- Otoliths from the four sites combined were 2% wild and 98% hatchery.
- Fewer eggs were delivered to the Van Dyke Hatchery, resulting in decreased production of hatchery larvae. In addition, too few adult shad passed upstream to provide significant natural reproduction, resulting in decreased production of juvenile American shad in the Susquehanna River basin.

ACKNOWLEDGMENTS

Normandeau Associates (Drumore, PA) was contracted by the PFBC to perform juvenile collections. Many individuals supplied information for this report. John Cingolani 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 lift net and river flow, Susquehanna River, 2008.

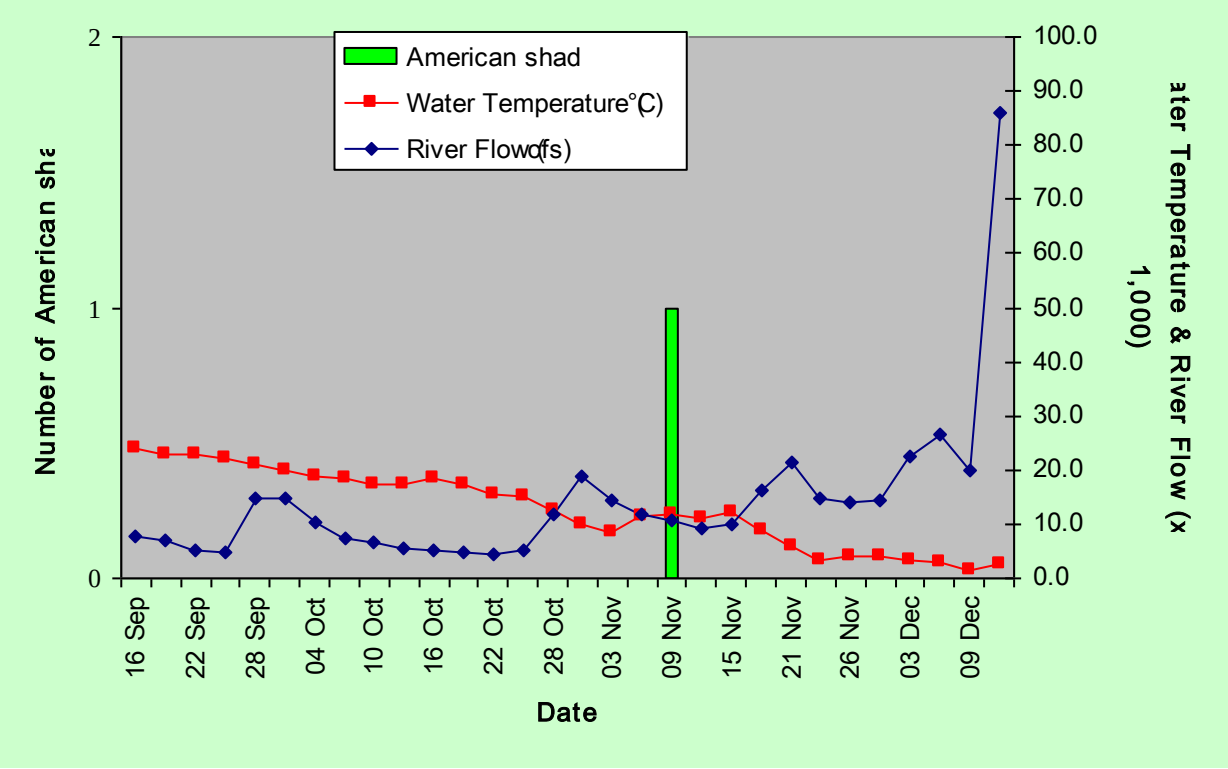

Figure 2. Annual YOY American shad CPUE for lift net collections in the Holtwood Dam forebay.

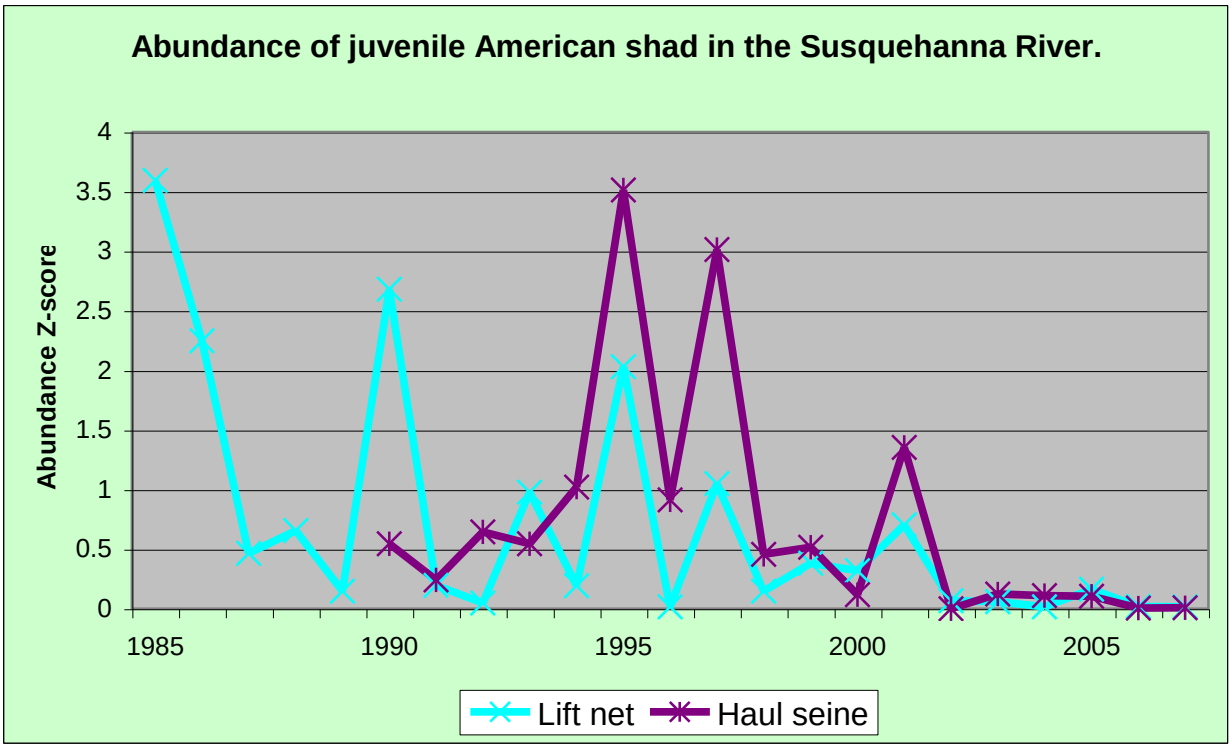

Table 1.

Number and percent composition of the fish collected by haul seine from the lower Susquehanna River near Columbia, Pennsylvania in 2008.

Date	7/16	7/22	7/29	8/5	8/13	8/19	8/27	9/2	9/10	9/16	9/24	10/1	10/8	10/15	10/21	Total	%
Daily Mean River Flow(cfs)	11,100	9,440	18,200	9,415	9,190	9,570	5,580	5,510	7,620	7,670	4,840	14,900	8,150	6,040	4,400		
Water Temperature°(C)	27.0	28.5	26.5	25.5	25.5	26.5	26.5	26.0	22.5	22.0	23.0	20.0	18.0	19.5	16.0		
Secchi Disk(t)	57	60	43	38	29	36	60	45	60	90	90	41	70	73	70		
Gizzard shad	248	261	121	48	53	155	18	39	30	57	7	61	60	3	-	1,161	56.3%
Common carp	17	4	12	4	1	3	-	1	-	1	2	-	-	1	-	46	2.2%
Comely shiner	9	1	1	1	-	6	3	-	2	-	4	-	2	-	-	29	1.4%
Common shiner	-	-	5	-	-	-	2	-	-	-	-	-	-	-	-	7	0.3%
Spottail shiner	-	-	1	-	-	-	-	-	-	-	-	-	2	-	-	3	0.1%
Spotfin shiner	40	37	22	23	7	13	-	2	7	18	14	7	43	101	113	447	21.7%
Mimic shiner	-	-	-	-	-	1	-	1	-	-	-	2	-	1	-	5	0.2%
Bluntnose minnow	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2	0.1%
Fallfish	9	3	20	8	6	3	-	5	2	12	3	4	18	5	14	112	5.4%
Quillback	27	22	10	19	39	19	-	13	26	3	5	1	1	-	-	185	9.0%
Channel catfish	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	3	0.1%
Banded killifish	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	0.1%
Mosquitofish	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	2	0.1%
Rock bass	-	-	-	-	-	-	-	-	-	4	1	3	1	1	-	10	0.5%
Redbreast sunfish	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	0.0%
Bluegill	-	-	-	-	-	2	-	-	6	1	-	3	-	25	1	38	1.8%
Smallmouth bass	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.0%
Tessellated darter	1	-	6	-	-	1	-	-	-	-	1	-	-	-	-	9	0.4%
Total	351	331	198	103	106	204	23	63	73	96	37	84	127	138	129	2,063	100.0%
No. of Species	7	9	9	6	5	10	3	7	6	7	8	9	7	8	4	18	

Table 2. Index of abundance for juvenile American shad collected by haul seine at Marietta, Columbia and Wrightsville, Susquehanna River, 1990-2008.

		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		0	0.15	0.11	272	4.25	1.18
1991	144	170	1.01	0.54		80	0.48	0.35	90	0.53	0.21
1992	92	269	4.24	1.45		146	2.49	0.78	172	2.63	0.91
1993	111	218	1.90	1.22		174	1.61	1.01	44	0.29	0.19
1994	110	390	4.74	2.29		254	3.19	1.38	322	3.64	2.04
1995	48	409	8.92	7.89		58	1.29	1.06	351	7.63	6.85
1996	105	283	2.89	2.05		157	1.61	1.20	126	1.28	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	2.46	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	-	0.00	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
2008	90	0	0.00	0.00	0.00	0	0.00	0.00	0	0.00	0.00

Table 3. Weekly catch of juvenile American shad by haul seine from the lower Susquehanna River, 1989 through 2008.

	July				August				September				October				November		
	1-7	8-15	16-23	24-31	1-7	8-15	16-23	24-31	1-7	8-15	16-23	24-30	1-7	8-15	16-23	24-31	1-7	8-15	TOTAL
1989	-	1,048	-	45	-	61	7	-	-	-	-	-	-	-	-	-	-	-	**1,161**
1990	-	-	-	31	0	0	69	-	25	97	28	0	0	0	-	-	-	-	**250**
1991	-	0	0	-	0	0	0	-	12	16	30	73	69	7	5	0	-	-	**212**
1992	0	120	6	-	20	2	16	-	-	-	-	-	2	-	-	0	-	-	**166**
1993	-	0	-	0	0	8	0	13	20	41	27	11	22	0	-	-	-	-	**142**
1994	2	27	70	60	24	13	46	-	-	75	14	5	5	2	10	-	-	-	**353**
1995	-	-	53	24	29	35	40	42	43	65	46	15	19	31	-	0	-	-	**442**
1996	-	2	18	15	32	56	43	39	34	4	12	15	10	3	-	0	-	-	**283**
1997	-	44	28	22	14	20	171	120	129	135	59	32	91	0	14	-	-	-	**879**
1998	-	-	24	144	30	0	9	10	3	3	4	0	3	0	0	-	-	-	**230**
1999	-	0	0	1	1	0	0	10	*	264	17	20	1	3	5	-	-	-	**322**
2000	-	7	3	0	2	6	1	0	0	0	0	1	0	11	0	-	-	-	**31**
2001	-	-	46	42	70	37	36	36	23	31	15	34	6	1	0	0	-	-	**377**
2002	-	-	0	0	0	0	0	0	0	0	0	0	0	0	*	0	-	-	**0**
2003	-	-	0	0	*	*	0	8	5	4	0	*	*	0	*	*	-	-	**17**
2004	-	0	0	*	*	0	*	16	5	4	*	*	0	0	0	0	-	-	**25**
2005	-	-	2	0	5	1	2	2	3	0	1	2	0	2	3	*	*	0	**23**
2006	-	-	*	*	0	0	0	0	*	0	0	0	0	0	1	-	-	-	**1**
2007	-	-	0	2	0	0	0	0	0	0	0	0	0	0	0	-	-	-	**2**
2008	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	**0**
Total	2	1,248	250	386	227	239	440	296	302	739	253	208	228	60	38	0	0	0	**4,916**

* No sampling due to high river flow.

Table 4. Fishes collected by an 8 x 8 ft lift net from Holtwood Power Station inner forebay, 2008.

Date:	*9/16*	*9/19*	*9/22*	*9/25*	*9/28*	*10/1*	*10/4*	*10/7*	*10/10*	*10/13*	*10/16*	*10/19*	*10/22*	*10/25*	*10/28*	*10/31*
Water Temp (°C):	*24.0*	*23.0*	*22.8*	*22.0*	*21.0*	*20.0*	*19.0*	*18.5*	*17.5*	*17.5*	*18.5*	*17.5*	*15.5*	*15.0*	*12.5*	*10.0*
Secchi (in):	*39*	*34*	*44*	*30*	*36*	*39*	*48*	*50*	*80*	*86*	*45*	*60*	*63*	*46*	*40*	*55*
River Flow (cfs):	*7,670*	*7,120*	*5,190*	*4,840*	*14,600*	*14,900*	*10,400*	*7,305*	*6,570*	*5,520*	*5,030*	*4,880*	*4,300*	*5,190*	*11,700*	*18,900*
Start Time (hr):	*1900*	*1855*	*1846*	*1849*	*1833*	*1752*	*1800*	*1815*	*1758*	*1805*	*1730*	*1732*	*1726*	*1736*	*1716*	*1744*
End Time (hr):	*2010*	*2017*	*2018*	*2025*	*2020*	*1917*	*1938*	*1938*	*1930*	*1925*	*1907*	*1858*	*1859*	*1901*	*1844*	*1906*
American shad	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gizzard shad	493	24	23	345	299	7	160	15	121	86	339	62	82	1	6	36
Comely shiner	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
Spottail shiner	-	16	-	-	-	-	1	-	1	3	33	-	-	2	-	-
Spotfin shiner	5	-	-	-	2	16	34	8	12	61	7	8	6	-	-	-
Mimic shiner	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Bluntnose minnow	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Channel catfish	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Bluegill	-	1	-	-	-	-	-	12	2	3	-	-	-	-	-	2
Total	***498***	***41***	***24***	***345***	***302***	***23***	***196***	***35***	***136***	***153***	***381***	***70***	***88***	***4***	***6***	***38***
No. of Species	***2***	***3***	***2***	***1***	***3***	***2***	***4***	***3***	***4***	***4***	***4***	***2***	***2***	***3***	***1***	***2***

Table 1

Continued.

Date:	*11/3*	*11/6*	*11/9*	*11/12*	*11/15*	*11/18*	*11/21*	*11/24*	*11/26*	*11/30*	*12/3*	*12/6*	*12/9*	*12/12*		
Water Temp (°C):	*8.5*	*11.5*	*11.9*	*11.0*	*12.0*	*9.0*	*6.0*	*3.5*	*4.0*	*4.0*	*3.5*	*3.0*	*1.5*	*2.5*		
Secchi (in):	*42*	*20*	*40*	*45*	*60*	*39*	*55*	*72*	*60*	*60*	*43*	*51*	*60*	*24*		
River Flow (cfs):	*14,400*	*11,750*	*10,600*	*9,350*	*10,100*	*16,200*	*21,500*	*14,900*	*14,000*	*14,300*	*22,600*	*26,450*	*19,900*	*86,100*		
Start Time (hr):	*1632*	*1622*	*1644*	*1620*	*1623*	*1612*	*1619*	*1611*	*1600*	*1600*	*1600*	*1605*	*1557*	*1551*		
End Time (hr):	*1745*	*1752*	*1818*	*1743*	*1755*	*1730*	*1751*	*1733*	*1736*	*1736*	*1726*	*1732*	*1733*	*1731*	***TOTAL***	***%***
American shad	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	0.0
Gizzard shad	1	2	310	61	69	31	-	-	-	-	-	-	-	1	2,574	90.9
Comely shiner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.1
Spottail shiner	-	-	2	-	-	1	-	-	-	-	-	-	-	-	59	2.1
Spotfin shiner	-	-	3	2	1	-	-	-	-	-	-	-	-	-	165	5.8
Mimic shiner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.0
Bluntnose minnow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.1
Channel catfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.0
Bluegill	2	-	-	3	-	-	-	-	-	-	-	-	-	1	26	0.9
Total	***3***	***2***	***316***	***66***	***70***	***32***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***2***	***2,831***	***100.0***
No. of Species	***2***	***1***	***4***	***3***	***2***	***2***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***2***	***9***	

Table 5. Index of abundance for juvenile American shad collected by lift net in the forebay of Holtwood Hydroelectric Station, 1985-2008.

		Total					Wild				Hatchery			
Year	No. Lifts	No. Fish	Mean Combined Daily CPUE	GM Combined Daily CPUE	GM Individual Lift CPUE*	Area under curve CPUE	No. Fish	Mean Combined Daily CPUE (Wild)	GM Combined Daily CPUE (Wild)	Area under curve CPUE	No. Fish	Mean Combined Daily CPUE (Hatchery)	GM Combined Daily CPUE (Hatchery)	Area under curve CPUE
1985	378	3,626	20.31	7.55		1422	***	***						
1986	404	2,926	10.30	5.71		888	***	***						
1987	428	832	3.17	1.90		178	***	***						
1988	230	929	3.87	1.28		254	***	***						
1989	286	556	0.86	0.43		53	***	***						
1990	290	3,988	13.75	3.67		1059	70	0.24	0.18	16	3,984	13.74	3.66	1042
1991	370	208	0.56	0.39		72	19	0.05	0.05	7	189	0.51	0.36	65
1992	250	39	0.16	0.12		13	14	0.06	0.05	5	25	0.10	0.08	9
1993	250	1,095	4.38	1.20		383	669	2.79	0.86	233	426	1.70	0.72	149
1994	250	206	0.82	0.48		71	35	0.15	0.13	12	171	0.68	0.42	59
1995	115	1,048	9.11	1.26	1.07	801	83	0.72	0.32	53	965	8.39	1.01	742
1997	300	1,372	4.57	0.88	0.61	411	100	0.33	0.23	30	1,272	4.24	0.85	381
1998	300	180	0.60	0.37	0.22	53	9	0.03	0.03	2	171	0.57	0.35	49
1999	300	490	1.63	0.78	0.50	145	19	0.06	0.07	5	471	1.57	0.76	140
2000	300	406	1.35	0.61	0.18	121	4	0.01	0.01	1	402	1.34	0.60	120
2001	299	1,245	4.18	1.37	0.43	273	538	1.81	0.45	112	707	2.38	0.99	161
2002	220	68	0.31	0.15	0.09	20	15	0.07	0.05	3	53	0.24	0.13	16
2003	300	61	0.20	0.13	0.07	17	3	0.01	0.01	1	58	0.23	0.15	17
2004	240	0	0.00	0.00	0.00	0	0	0.00	0.00	0	0	0.00	0.00	0
2005	300	200	0.67	0.15	0.10	59	47	0.16	0.11	13	153	0.00	0.00	46
2006	230	8	0.03	0.03	0.01	1.6	0	0.00	0.00	0	8	0.03	0.03	1.6
2007	300	0	0.00	0.00	0.00	0	0	0.00	0.00	0	0	0.00	0.00	0
2008	300	1	0.004	0.004	0.002	0.2	0	0.00	0.00	0	1	0.003	0.003	0.2

* Required by ASMFC

**Mean flow during outmigration.

***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				September				October				November				December				Total	Total	
Year	1-7	8-15	16-23	24-31	1-7	8-15	16-23	24-30	1-7	8-15	16-23	24-31	1-7	8-15	16-23	24-31	1-7	8-15	16-23	24-31	shad	lifts	CPUE
1985	-	-	-	-	-	-	-	-	-	-	0.12	1.00	41.60	28.63	10.79	36.37	62.80	4.30	0.51	-	3,626	378	9.59
1986	-	-	-	-	-	-	-	-	-	16.67	30.29	5.40	5.29	4.09	19.52	6.31	14.20	0.11	0.00	-	2,926	404	7.24
1987	-	-	-	-	-	1.25	0.69	0.28	0.89	4.08	4.50	1.25	4.78	4.47	0.25	0.67	0.00	-	-	-	832	428	1.94
1988	-	-	-	-	0.00	-	-	-	0.00	0.09	0.00	9.97	19.07	2.00	0.25	0.35	0.00	-	-	-	929	230	4.04
1989	-	-	-	-	-	-	2.30	-	1.20	1.20	3.22	0.50	0.00	0.00	0.00	-	-	-	-	-	556	286	1.94
1990	-	-	0.00	0.00	0.00	0.00	0.00	7.55	3.87	6.93	65.13	43.63	5.33	0.50	0.20	0.00	-	-	-	-	3,988	290	13.75
1991	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.55	0.90	1.10	2.40	0.50	1.18	-	1.20	0.00	-	208	370	0.56
1992	-	-	0.00	0.00	0.00	0.00	0.05	0.00	0.90	0.03	0.45	0.50	0.00	0.00	0.00	-	-	-	-	-	39	240	0.16
1993	-	-	-	-	0.00	0.00	0.00	0.30	0.20	0.20	0.10	17.50	14.80	19.00	1.60	0.10	-	-	-	-	1,095	240	4.56
1994	-	-	-	-	-	0.23	0.00	0.10	4.30	3.55	0.75	0.23	0.70	0.10	0.03	0.00	0.00	-	-	-	206	250	0.82
1995	-	0.00	0.00	0.00	0.00	0.00	-	0.00	0.10	0.00	5.05	68.90	56.05	9.30	0.00	0.00	-	-	-	-	2,100	230	9.13
1997	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	25.10	27.10	1.46	0.00	-	-	-	1,372	300	4.57
1998	-	-	-	-	-	0.00	0.00	0.00	0.05	0.80	2.07	2.45	1.07	0.10	0.10	0.05	0.00	0.60	-	-	180	300	0.60
1999	-	-	-	-	-	0.00	6.67	0.30	4.67	3.65	1.87	0.50	0.00	0.00	0.00	0.00	0.00	0.00	-	-	490	300	1.63
2000	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.20	1.17	1.45	2.80	7.23	1.85	0.00	0.00	-	-	406	300	1.35
2001	-	-	-	-	-	0.00	0.00	0.00	0.50	0.07	0.13	0.90	1.90	7.30	6.67	2.75	23.37	-	-	-	1,245	300	4.15
2002	-	-	-	-	-	-	-	0.00	0.00	0.03	3.30	0.03	0.00	0.00	0.00	0.00	0.00	0.00	-	-	68	260	0.26
2003	-	-	-	-	-	-	0.00	0.00	1.30	0.50	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	61	300	0.20
2004	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	240	0.00
2005	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	6.67	0.00	0.00	0.00	0.00	-	-	-	-	200	270	0.74
2006	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	-	-	-	-	-	-	8	230	0.03
2007	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	300	0.00
2008	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	-	-	-	1	300	0.003

* 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, 2008.

Species	Unit 2	Unit 3	Total
Alewife	8	5	**13**
Blueback herring	0	0	**0**
American shad	25	21	**46**
Gizzard shad	21,055	12,345	**33,400**
Carp	3	4	**7**
Comely shiner	1	0	**1**
Spottail shiner	3	2	**5**
Spotfin shiner	1	1	**2**
Quillback	0	1	**1**
Channel catfish	51	68	**119**
Flathead catfish	1	0	**1**
Rock bass	2	4	**6**
Green sunfish	5	14	**19**
Bluegill	3,239	6,361	**9,600**
Largemouth bass	0	1	**1**
White crappie	5	55	**60**
Black crappie	0	1	**1**
Walleye	7	6	**13**
Tessellated darter	1	1	**2**
Logperch	0	1	**1**
Crayfish	36	40	**76**
TOTAL	***24,443***	***18,931***	***43,374***

Table 8. Number of juvenile American shad collected during intake screen sampling by unit at Peach Bottom Atomic Power Station in fall, 2008.

Date	Unit 2	Unit 3	Total
03 Nov	1	0	**1**
05 Nov	8	4	**12**
07 Nov	2	5	**7**
12 Nov	1	0	**1**
21 Nov	1	2	**3**
24 Nov	1	0	**1**
26 Nov	1	0	**1**
01 Dec	0	1	**1**
03 Dec	1	0	**1**
05 Dec	1	1	**2**
08 Dec	3	8	**11**
10 Dec	5	0	**5**
TOTAL	***25***	***21***	***46***

Table 9. Species and number of fish collected during cooling water intake sampling at Conowingo Dam in Fall, 2008.

Species	Francis Units (7)	Kaplan Units (4)	Total
American shad	1	0	**1**
Gizzard shad	5,147	3,562	**8,709**
Alewife	2	0	**2**
Blueback herring	0	0	**0**
Channel catfish	2	0	**2**
Spottail shiner	1	1	**2**
Pumpkinseed	1	0	**1**
White crappie	0	1	**1**
Tessellated darter	1	0	**1**
TOTAL	***5,155***	***3,564***	***8,719***

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
10 Nov	1	0	**1**
TOTAL	***1***	***0***	***1***

Table 11. Catch of juvenile American shad by location from the upper Chesapeake Bay during the 2008 Maryland DNR juvenile finfish haul seine survey.

Permanent Sites

Location	Round 1	Round 2	Round 3	Totals
HOWELL PT.	0	0	0	0
TIMS CR	0	0	0	0
SASSAFRAS NRMA	0	0	0	0
PARLOR PT.	0	0	0	0
ELK NECK PARK	0	0	0	0
WELCH PT.	0	0	0	0
HYLAND PT.	1	0	1	2
Total	1	0	1	2
Mean Catch Per Haul	**0.25**	**0.00**	**0.25**	

Auxiliary Sites

Location	Round 1	Round 2	Round 3	Totals
CARPENTER PT	0	0	0	0
POPLAR PT	no haul	no haul	no haul	0
PLUM PT	0	0	0	0
SPOIL ISLAND	0	0	0	0
TYDINGS ESTATE	0	0	0	0
TOLCHESTER	0	0	0	0
Total	0	0	0	0
Mean	**0.00**	**0.00**	**0.00**	

Table 12. Analysis of juvenile American shad otoliths collected in the Susquehanna River, 2008.

		Immersion marks								
		Day 15,18,21	Days 3,6,9,17	Days 15,18,21,24	Days 3,8,11,14,17	Days 3,6,11,17,20				
Collection Site	Coll. Date	Jun. R./ Susq. R.	N. Br. Susq. (PA)	W. Br. Susq.	W. Br. Susq.	Swatara Cr.	Total Hatchery	Total Wild	Total Processed	Total Collected
Holtwood	11/9/08	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1	1
Peach Bottom	11/3/08	1.0	0.0	0.0	0.0	0.0	1.0	0.0	1	1
Impingement	11/5/08	0.0	2.0	9.0	1.0	0.0	12.0	0.0	12	12
	11/7/08	2.0	1.0	4.0	0.0	0.0	7.0	0.0	7	7
	11/12/08	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1	1
	11/21/08	0.0	1.0	1.0	0.0	1.0	3.0	0.0	3	3
	11/24/08	0.0	1.0	0.0	0.0	0.0	1.0	0.0	1	1
	11/26/08	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1	1
	12/1/08	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1	1
	12/3/08	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1	1
	12/5/08	0.0	0.0	1.0	0.0	0.0	1.0	1.0	2	2
	12/8/08	2.2	0.0	4.4	3.3	1.1	11.0	0.0	10	11
	12/10/08	1.0	0.0	2.0	1.0	1.0	5.0	0.0	5	5
Conowingo Strainers	11/10/08	0.0	0.0	1.0	0.0	0.0	1.0	0.0	1	1
Holt./P. Bot./Con.		6.0	6.0	24.0	7.0	3.0	46.0	1.0	47	48
Percent		12.5%	12.5%	50.0%	14.6%	6.3%	95.8%	2.1%		
Grand Total		6.2	6.0	24.4	7.3	3.1	47.0	1.0 **	47	48
Percent		12.9%	12.5%	50.8%	15.2%	6.5%	97.9%	2.1%		

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