

# **ABUNDANCE AND DISTRIBUTION OF JUVENILE AMERICAN SHAD IN THE SUSQUEHANNA RIVER, 2009**

*Abridged report for PFBC Website*

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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 2009.

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 6,534 adult shad were collected at the Conowingo West Lift. The majority were released back into the Conowingo tailrace, with 1003 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 2009 spring migration, Conowingo East Lift passed 29,272 American shad while fishways at Holtwood, Safe Harbor, and York Haven passed 10,896, 7,994, and 402 American shad, respectively. Some 71 blueback herring and 160 alewife were passed at Conowingo Dam. One alewife was passed at Holtwood but no other 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 2009 production season, the PFBC Van Dyke Research Station for Anadromous Fish produced 2.7 million shad larvae which were released in the Susquehanna Basin in Pennsylvania. Larval releases occurred from 28 May to 19 June during a period of steadily decreasing flows. Larvae were released in the following locations and numbers:

North Branch Susquehanna River (PA)	455,432
West Branch Susquehanna River	1,256,078
Conodoguinet Creek	484,905
Mouth of Conodoguinet Creek	487,268
Mouth of Conoy Creek	17,274

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 (GM 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. Fourteen weekly sampling events were conducted in 2009. 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 15 September and continued every third day through 11 December 2009, 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 2009. Intake screen sampling was conducted daily, (Monday through Friday), from 28 October to 4 December, 2009. Sixteen 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 12 October through 4 December 2008. Sampling occurred twice weekly during this period for a total of 15 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 2009. Catches generally peaked in August and September, except in 1989 and 1992 when catches peaked in July, and in 2005 -2009 when there was no peak.

#### Holtwood Dam, Peach Bottom APS, and Conowingo Dam

No juvenile American shad were captured by lift-netting at Holtwood Dam inner fore-bay (Table 4). GM CPUE (individual lift) and GM CPUE (combined daily) were 0.000 (Table 5). AUC was also 0.0. 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 6 juvenile American shad, 3 alewife and one blueback herring between 28 October and 4 December (Table 7).

Cooling water intake strainers at Conowingo produced 2 American shad collected on 26 October and 2 collected on 2 November (Tables 8 and 9). Two alewives and no blueback herring were collected in strainer samples in 2009.

#### 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 7 juvenile American shad were collected in Peach Bottom intakes and Conowingo strainers. All of the 6 specimens evaluated for hatchery tags were hatchery and all were stocked in the West Branch Susquehanna River.

### **DISCUSSION**

River conditions for the Susquehanna River Basin during 2009 could be characterized by varying flows caused by numerous rain events throughout spring and summer (Figure 1). High water events at Marietta occurred on 7 May, 19 May, 30 May, 23 June, 3 August, and 14 August. Stocking of 8 tanks was delayed by high river flows and these tanks were ultimately diverted from the Juniata River to the West Branch Susquehanna River or Conodoguinet Creek (Figure 2). No shad larvae were stocked in the Juniata River in 2009 due to persistent high flows.

Fish passage at Conowingo Dam improved from 2008 with 29,272 shad passed, but was still well below the levels passed during 2000 to 2004. Fish passage efficiency at Holtwood (10,896) was better than average with 37% passage, based on counts at Conowingo and Holtwood (long-term mean = 32%). Fish passage at Safe Harbor (7,994) was 73%, close to the long-term mean of 71%, based on counts at Holtwood and Safe Harbor. Fish passage at York Haven (402) was 5%, lower than the long-term mean of 10%, 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 2009, no juvenile shad were collected by haul seine or lift net. Haul seining produced no shad in 2002 and 2008 (Table 2), while lift netting produced no shad in 2004 and 2007 (Table 5), but this was the first year of record that both the haul seine and lift net caught no shad.

GM CPUE for haul seine (both individual lifts, and combined daily lifts, (Table 2) was 0.00. GM CPUE for lift net collections (Table 5) in the Holtwood Dam forebay was 0.00. 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 2014. 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, and poor fish

passage. The poor catch rate in 2008 and 2009 was likely due to decreased egg deliveries and poor fish passage.

### Stock Composition and Mark Analysis

Hatchery contribution was 100% for all sites combined with all six shad processed exhibiting hatchery marks. All six juvenile shad collected were stocked in the West Branch Susquehanna River based on their OTC mark patterns.

### SUMMARY

- Juvenile American shad were collected 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 0.00 was the lowest recorded for that gear type for the period of record. Lift net AUC (0.00) was the lowest recorded for the period of record.
- Otoliths from the two sites combined were 100% 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. Discharge (cfs) at Marietta, 2009

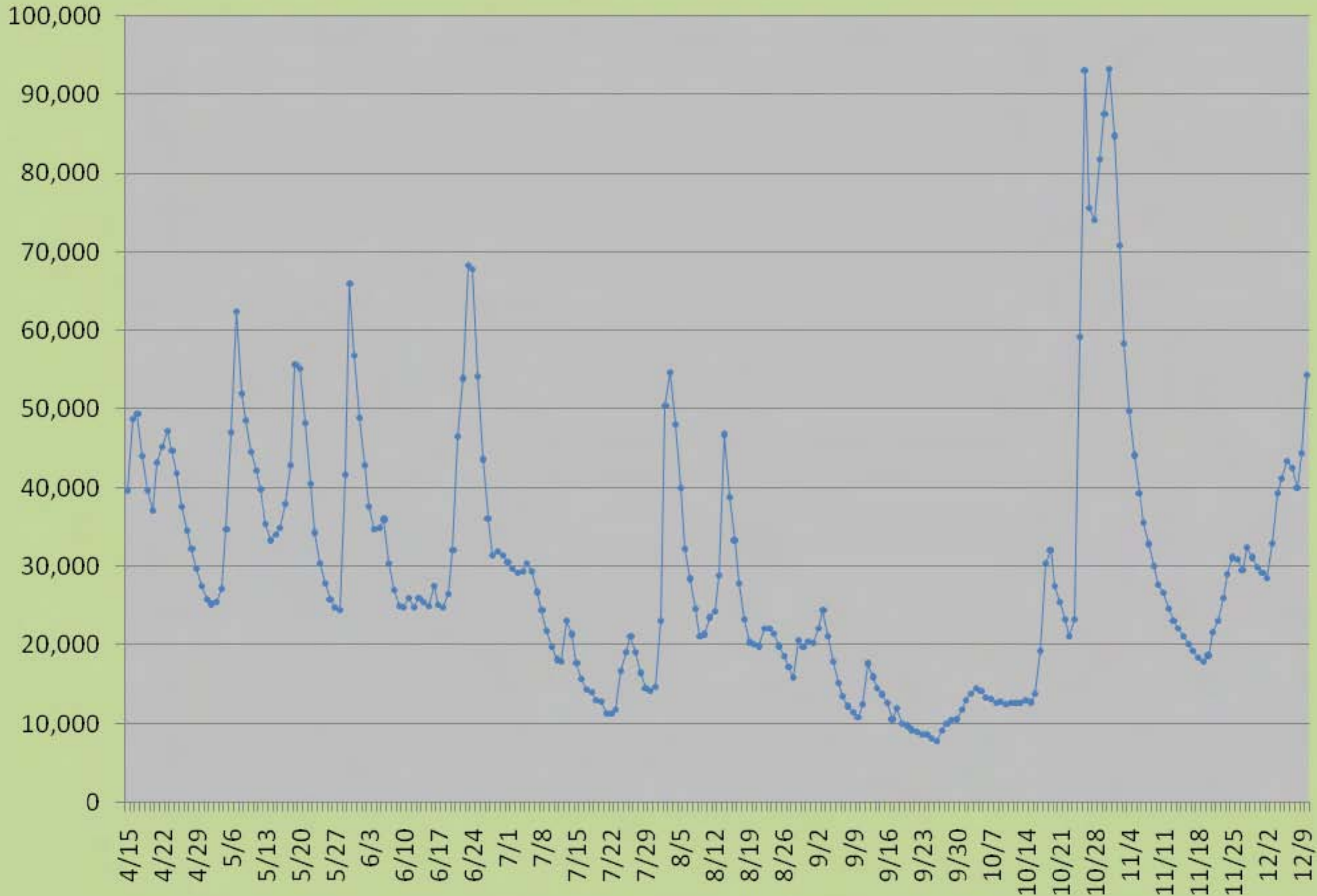


Figure 2. Discharge (cfs) at Newport (Juniata) and Williamsport (W. Branch), 2009

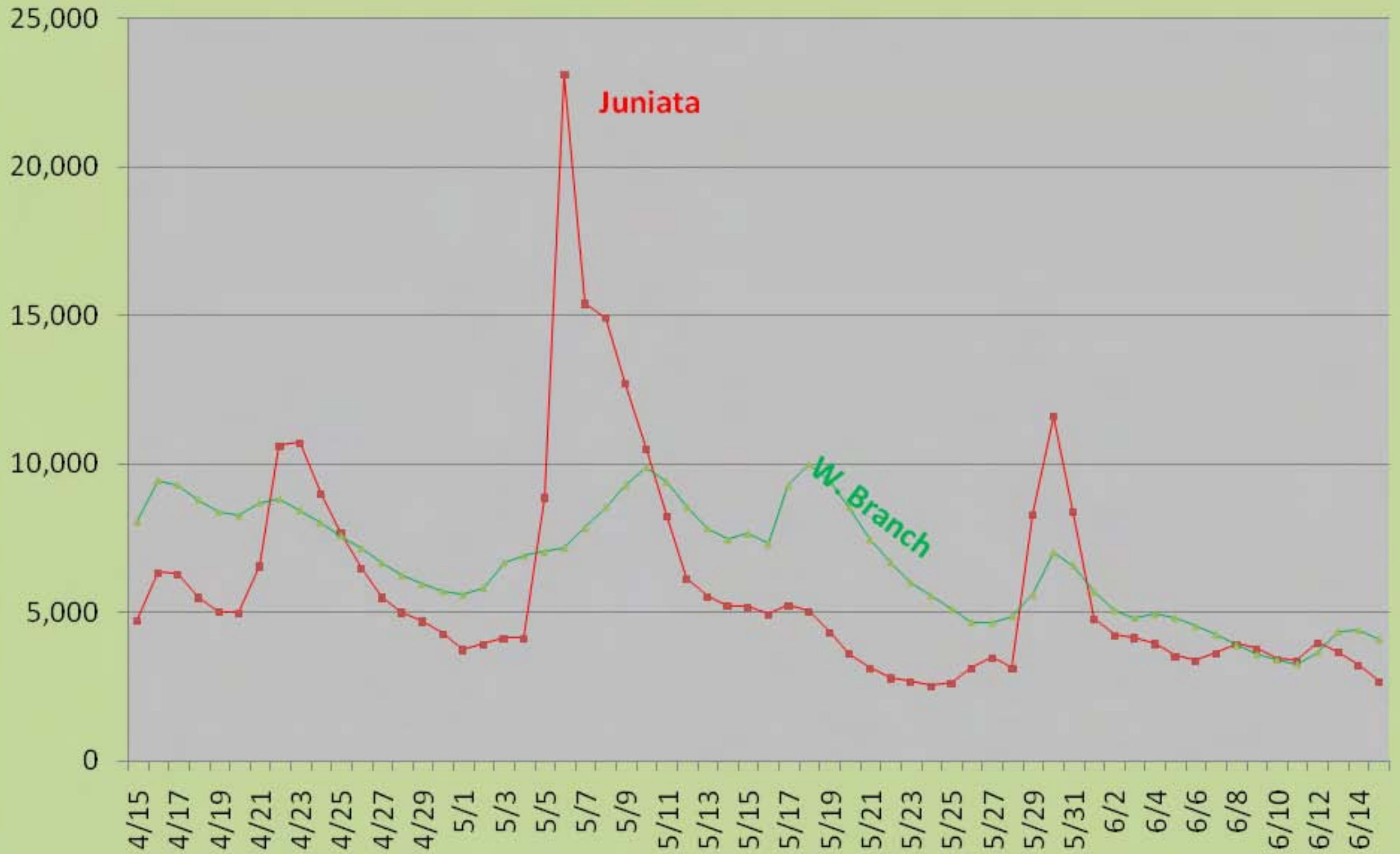
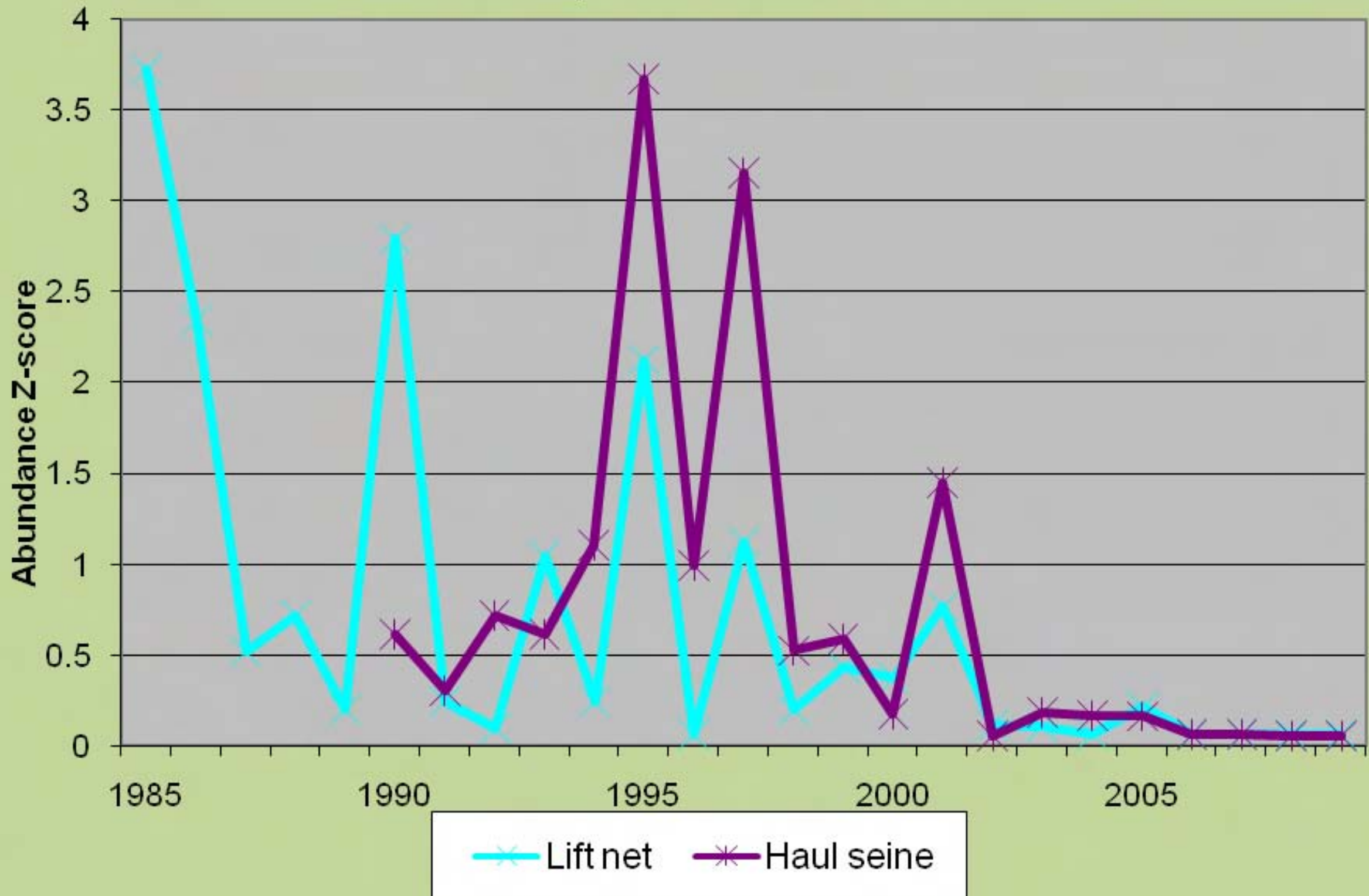


Figure 3. Abundance of juvenile American shad in the Susquehanna River.



**Table 1. Number and percent composition of the fish collected by haul seine from the lower Susquehanna River near Columbia, Pennsylvania in 2009.**

Date	14-Jul	22-Jul	29-Jul	11-Aug	19-Aug	26-Aug	2-Sep	9-Sep	16-Sep	22-Sep	30-Sep	7-Oct	14-Oct	22-Oct	Total	%
Daily Mean River Flow (cfs)	19,250	11,250	14,200	23,740	19,400	18,100	24,550	11,200	12,120	8,560	10,800	13,150	12,600	22,500		
Water Temperature (°C)	23.0	23.0	23.0	26.5	28.5	26.5	22.5	23.5	21.5	21.5	18.5	17.0	14.2	14.0		
Secchi Disk (in)	18	40	30	24	28	20	17	37	38	72	45	42	60	44		
Gizzard shad	-	2	-	11	31	47	2	2	2	-	-	9	-	-	106	<b>11.3%</b>
Muskellunge	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	0.1%
Comely shiner	3	7	3	1	-	3	2	22	3	4	6	4	2	-	60	<b>6.4%</b>
Spottail shiner	3	10	-	-	-	-	1	8	-	8	8	-	19	21	78	<b>8.3%</b>
Spottin shiner	58	43	30	6	12	10	11	42	10	15	22	76	69	33	437	<b>46.7%</b>
Mimic shiner	-	-	-	6	8	-	-	-	2	-	-	-	1	-	17	1.8%
Bluntnose minnow	-	-	-	-	-	-	-	3	-	2	4	1	-	2	12	1.3%
Fallfish	3	8	4	5	5	10	10	3	1	1	18	10	1	-	79	<b>8.4%</b>
White sucker	-	5	-	-	-	3	1	-	-	-	-	-	-	-	9	1.0%
Northern hog sucker	-	-	5	-	-	-	-	-	-	-	-	-	-	-	5	0.5%
Channel catfish	2	4	1	-	-	3	12	-	1	-	-	-	-	-	23	<b>2.5%</b>
Flathead catfish	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	0.1%
Banded killifish	-	2	1	1	-	2	-	2	2	8	-	4	-	-	22	<b>2.4%</b>
Mosquitofish	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	0.1%
Rock bass	2	-	-	-	5	1	-	1	-	-	-	3	-	-	12	1.3%
Green sunfish	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1%
Bluegill	2	-	-	-	-	1	1	3	2	1	26	3	-	3	42	<b>4.5%</b>
Smallmouth bass	-	-	-	-	-	-	1	1	-	-	1	-	-	-	3	0.3%
White crappie	-	-	-	-	-	-	1	-	1	-	-	-	-	-	2	0.2%
Tessellated darter	-	1	3	-	-	4	-	3	1	6	2	-	-	1	21	<b>2.2%</b>
Walleye	1	1	-	1	-	-	-	1	-	-	-	-	-	-	4	0.4%
<b>Total</b>	<b>75</b>	<b>83</b>	<b>48</b>	<b>31</b>	<b>61</b>	<b>84</b>	<b>43</b>	<b>91</b>	<b>25</b>	<b>46</b>	<b>87</b>	<b>110</b>	<b>92</b>	<b>60</b>	<b>936</b>	<b>100.0%</b>
<b>No. of Species</b>	<b>9</b>	<b>10</b>	<b>8</b>	<b>7</b>	<b>5</b>	<b>10</b>	<b>11</b>	<b>12</b>	<b>10</b>	<b>9</b>	<b>8</b>	<b>8</b>	<b>5</b>	<b>5</b>	<b>21</b>	

Table 2. Index of abundance for juvenile American shad collected by haul seine at Marietta, Columbia and Wrightsville, 1990-2009.

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)	No. Hatchery 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
2008	90	0	0.00	0.00	0.00	0	0.00	0.00	0	0.00	0.00
2009	84	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 2009.**

Month	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	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	0	0	250
24-31 Jul	45	31	-	-	0	60	24	15	22	144	1	0	42	0	0	*	0	*	2	0	0	386
1-7 Aug	-	0	0	20	0	24	29	32	14	30	1	2	70	0	*	*	5	0	0	0	*	227
8-15 Aug	61	0	0	2	8	13	35	56	20	0	0	6	37	0	*	0	1	0	0	0	0	239
16-23 Aug	7	69	0	16	0	46	40	43	171	9	0	1	36	0	0	*	2	0	0	0	0	440
24-31 Aug	-	-	-	-	13	-	42	39	120	10	10	0	36	0	8	16	2	0	0	0	0	296
1-7 Sep	-	25	12	-	20	-	43	34	129	3	*	0	23	0	5	5	3	*	0	0	0	302
8-15 Sep	-	97	16	-	41	75	65	4	135	3	264	0	31	0	4	4	0	0	0	0	0	739
16-23 Sep	-	28	30	-	27	14	46	12	59	4	17	0	15	0	0	*	1	0	0	0	0	253
24-30 Sep	-	0	73	-	11	5	15	15	32	0	20	1	34	0	*	*	2	0	0	0	0	208
1-7 Oct	-	0	69	2	22	5	19	10	91	3	1	0	6	0	*	0	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	0	0	60
16-23 Oct	-	-	5	-	-	10	-	-	14	0	5	0	0	*	*	0	3	1	0	0	0	38
24-31 Oct	-	-	0	0	-	-	0	0	-	-	-	-	0	0	*	0	*	-	-	-	-	0
1-7 Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	0
8-15 Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	0
<b>TOTAL</b>	<b>1,161</b>	<b>250</b>	<b>212</b>	<b>166</b>	<b>142</b>	<b>353</b>	<b>442</b>	<b>283</b>	<b>879</b>	<b>230</b>	<b>322</b>	<b>31</b>	<b>377</b>	<b>0</b>	<b>17</b>	<b>25</b>	<b>23</b>	<b>1</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>4,916</b>

\* 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, 15 September through 11 December 2009.**

<b>Date:</b>	15 Sep	18 Sep	21 Sep	24 Sep	27 Sep	30 Sep	03 Oct	06 Oct	09 Oct	12 Oct	15 Oct	18 Oct	21 Oct	24 Oct	27 Oct	30 Oct
<b>Water Temp (°C):</b>	21.5	21.5	21.5	21.0	21.0	20.0	19.0	17.0	17.0	15.5	15.0	12.5	10.0	11.5	13.0	12.5
<b>Secchi (in):</b>	30	35	30	36	36	30	42	42	30	30	30	25	30	15	9	21
<b>River Flow (cfs):</b>	13,620	11,000	9,180	8,470	9,700	10,800	14,100	13,150	12,750	12,600	12,700	33,500	24,800	24,600	71,900	89,000
<b>Start Time (hr):</b>	1833	1836	1830	1826	1807	1810	1811	1803	1750	1743	1735	1719	1735	1724	1730	1735
<b>End Time (hr):</b>	1951	2007	1949	1953	1934	1940	1930	1922	1930	1915	1902	1850	1900	1837	1903	1902
Gizzard shad	140	208	97	2	-	255	87	50	2	18	13	4	-	-	-	-
Comely shiner	93	6	2	-	2	-	-	-	-	-	-	-	-	-	-	-
Spottail shiner	-	-	14	-	15	-	-	-	-	-	-	-	-	-	-	-
Spotfin shiner	-	17	23	18	-	62	33	11	1	5	-	-	-	-	-	5
Fallfish	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Banded killifish	-	-	-	-	-	-	-	-	-	-	-	1	6	-	-	-
Bluegill	-	-	-	-	-	-	-	-	-	-	-	2	3	-	-	3
Walleye	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Total</b>	<b>233</b>	<b>231</b>	<b>137</b>	<b>20</b>	<b>17</b>	<b>317</b>	<b>120</b>	<b>61</b>	<b>3</b>	<b>23</b>	<b>13</b>	<b>7</b>	<b>9</b>	<b>0</b>	<b>0</b>	<b>8</b>
<b>No. of Species</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>3</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>2</b>

**Table 4. Continued.**

<b>Date:</b>	02 Nov	05 Nov	08 Nov	11 Nov	14 Nov	17 Nov	20 Nov	23 Nov	25 Nov	29 Nov	02 Dec	05 Dec	08 Dec	11 Dec	<b>TOTAL</b>	<b>%</b>
<b>Water Temp (°C):</b>	12.5	11.0	9.0	9.3	9.0	10.5	11.5	10.5	10.0	8.5	7.5	7.0	5.0	3.0		
<b>Secchi (in):</b>	18	25	46	46	40	48	41	40	40	40	56	29	52	22		
<b>River Flow (cfs):</b>	68,100	43,000	32,100	26,100	21,900	18,700	18,800	26,800	31,500	30,700	28,400	42,500	39,400	56,700		
<b>Start Time (hr):</b>	1630	1629	1624	1620	1619	1612	1619	1610	1600	1558	1546	1600	1557	1605		
<b>End Time (hr):</b>	1745	1751	1755	1750	1748	1730	1751	1733	1729	1722	1713	1725	1730	1746	<b>1,238</b>	<b>100.0</b>
Gizzard shad	-	-	-	-	-	-	-	-	-	-	-	-	-	-	876	70.8
Comely shiner	-	-	-	-	-	-	-	-	-	1	-	-	-	-	104	8.4
Spottail shiner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	2.3
Spotfin shiner	-	-	6	8	-	-	-	-	-	-	1	-	-	-	190	15.3
Fallfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1
Banded killifish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	0.6
Bluegill	17	-	2	1	-	-	2	-	-	-	-	-	-	-	30	2.4
Walleye	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1
<b>Total</b>	<b>17</b>	<b>1</b>	<b>8</b>	<b>9</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1,238</b>	<b>100.0</b>
<b>No. of Species</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>8</b>	

Table 5. Index of abundance for juvenile American shad collected by lift net in the forebay of Holtwood Hydroelectric Station, 1985-2009.

Year	No. Lifts	Total					Wild				Hatchery			
		No. Fish	Mean Combined Daily CPUE	GM Combined Daily CPUE	GM Individual Lift CPUE*	Area under curve CPUE	No. Fish	Mean Combined Daily CPUE	GM Combined Daily CPUE	Area under curve CPUE	No. Hatchery Fish	Mean Combined Daily CPUE	GM Combined Daily CPUE	Area under curve CPUE
1985	378	3,626	20.31	7.55		1423								
1986	404	2,926	10.30	5.71		917								
1987	428	832	3.17	1.90		182								
1988	230	929	3.87	1.28		255								
1989	396	556	0.55	0.26		60								
1990	300	3,988	13.29	3.44		1060	70	0.23	0.18	17	3918	13.06	3.62	1043
1991	290	208	0.72	0.52		72	19	0.07	0.06	7	189	0.65	0.47	66
1992	300	39	0.13	0.10		14	14	0.05	0.04	5	25	0.08	0.07	9
1993	300	1,095	3.65	1.27		383	669	2.79	0.64	234	426	1.42	0.57	149
1994	300	206	0.69	0.39		71	35	0.13	0.13	12	171	0.57	0.32	59
1995	115	1,048	9.11	1.26		802	83	0.72	0.32	59	965	8.39	1.20	744
1997	300	1,372	4.57	0.88	0.61	412	100	0.33	0.23	30	1272	4.24	0.85	382
1998	300	180	0.60	0.37	0.22	53	9	0.03	0.03	3	171	0.57	0.35	50
1999	300	490	1.63	0.78	0.50	147	19	0.06	0.07	6	471	1.57	0.76	141
2000	300	406	1.35	0.61	0.18	122	4	0.01	0.01	1	402	1.34	0.60	121
2001	299	1,245	4.18	1.37	0.43	322	538	1.81	0.45	135	707	2.36	0.99	186
2002	300	68	0.23	0.11	0.06	20	15	0.05	0.04	5	53	0.18	0.09	16
2003	300	61	0.20	0.13	0.07	18	3	0.01	0.01	1	58	0.19	0.12	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	60	47	0.16	0.11	14	153	0.51	0.11	46
2006	230	0	0.00	0.00	0.01	0	0	0.00	0.00	0	0	0.00	0.00	0
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
2009	300	0	0.000	0.000	0.000	0.0	0	0.00	0.00	0	0	0.000	0.000	0.0

\* Required by ASMFC

**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 - 2009.**

Week	Historical Years															
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1997	1998	1999	2000	2001
1-7 Aug	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-15 Aug	-	-	-	-	-	-	0.00	-	-	-	0.00	-	-	-	-	-
16-23 Aug	-	-	-	-	-	0.00	0.00	0.00	-	-	0.00	-	-	-	-	-
24-31 Aug	-	-	-	-	-	0.00	0.00	0.00	-	-	0.00	-	-	-	-	-
1-7 Sep	-	-	-	0.00	-	0.00	0.00	0.00	0.00	-	0.00	-	-	-	-	-
8-15 Sep	-	-	1.25	-	-	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00
16-23 Sep	-	-	0.69	-	2.30	0.00	0.00	0.05	0.00	0.00	-	0.00	0.00	6.67	0.00	0.00
24-30 Sep	-	-	0.28	-	-	7.55	0.00	0.00	0.30	0.10	0.00	0.00	0.00	0.30	0.00	0.00
1-7 Oct	-	-	0.89	0.00	1.20	3.87	0.10	0.90	0.20	4.30	0.10	0.00	0.05	4.67	0.00	0.50
8-15 Oct	-	16.67	4.08	0.09	1.20	6.93	0.10	0.03	0.20	3.55	0.00	0.00	0.80	3.65	0.00	0.07
16-23 Oct	0.12	30.29	4.50	0.00	3.22	65.13	0.55	0.45	0.10	0.75	5.05	0.00	2.07	1.87	0.20	0.13
24-31 Oct	1.00	5.40	1.25	9.97	0.50	43.63	0.90	0.50	17.50	0.23	68.90	0.20	2.45	0.50	1.17	0.90
1-7 Nov	41.60	5.29	4.78	19.07	0.00	5.33	1.10	0.00	14.80	0.70	56.05	0.00	1.07	0.00	1.45	1.90
8-15 Nov	28.63	4.09	4.47	2.00	0.00	0.50	2.40	0.00	19.00	0.10	9.30	25.10	0.10	0.00	2.80	7.30
16-23 Nov	10.79	19.52	0.25	0.25	0.00	0.20	0.50	0.00	1.60	0.03	0.00	27.10	0.10	0.00	7.23	6.67
24-30 Nov	36.37	6.31	0.67	0.35	-	0.00	1.18	-	0.10	0.00	0.00	1.46	0.05	0.00	1.85	2.75
1-7 Dec	62.80	14.20	0.00	0.00	-	-	-	-	-	0.00	-	0.00	0.00	0.00	0.00	23.37
8-15 Dec	4.30	0.11	-	-	-	-	1.20	-	-	-	-	-	0.60	0.00	0.00	-
16-23 Dec	0.51	0.00	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-
24-31 Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Total shad</b>	3,626	2,926	832	929	556	3,988	208	39	1,095	206	2,100	1,372	180	490	406	1,245
<b>Total lifts</b>	378	404	428	230	286	290	370	240	240	250	230	300	300	300	300	300
<b>CPUE</b>	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

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

**Table 6. Continued.**

Week	Historical Years							Year
	2002	2003	2004	2005	2006	2007	2008	2009
1-7 Aug	-	-	-	-	-	-	-	-
8-15 Aug	-	-	-	-	-	-	-	-
16-23 Aug	-	-	-	-	-	-	-	-
24-31 Aug	-	-	-	-	-	-	-	-
1-7 Sep	-	-	-	-	-	-	-	-
8-15 Sep	-	-	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
16-23 Sep	-	0.00	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
24-30 Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
1-7 Oct	0.00	1.30	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
8-15 Oct	0.03	0.50	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
16-23 Oct	3.30	0.27	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
24-31 Oct	0.03	0.00	0.00	6.67	0.20	0.00	0.00	<b>0.00</b>
1-7 Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<b>0.00</b>
8-15 Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.10	<b>0.00</b>
16-23 Nov	0.00	0.00	0.00	0.00	-	0.00	0.00	<b>0.00</b>
24-30 Nov	0.00	0.00	0.00	0.00	-	0.00	0.00	<b>0.00</b>
1-7 Dec	0.00	0.00	0.00	-	-	0.00	0.00	<b>0.00</b>
8-15 Dec	0.00	0.00	-	-	-	-	-	<b>0.00</b>
16-23 Dec	-	-	-	-	-	-	-	-
24-31 Dec	-	-	-	-	-	-	-	-
<b>Total shad</b>	68	61	0	200	8	0	1	<b>0</b>
<b>Total lifts</b>	260	300	240	270	230	300	300	<b>300</b>
<b>CPUE</b>	0.26	0.20	0.00	0.74	0.03	0.00	0.003	<b>0.000</b>

**Table 7. Number of fish collected during intake screen sampling by unit at Peach Bottom Atomic Power Station, 28 October, to 4 December, 2009.**

<b>Species</b>	<b>Unit 2</b>	<b>Unit 3</b>	<b>Total</b>
Alewife	1	2	<b>3</b>
Blueback herring	1	0	<b>1</b>
American shad	5	1(Adult)	<b>6</b>
Gizzard shad	685	1,271	<b>1,956</b>
Carp	0	2	<b>2</b>
Comely shiner	6	4	<b>10</b>
Spottail shiner	2	1	<b>3</b>
Spotfin shiner	6	12	<b>18</b>
Bluntnose minnow	0	1	<b>1</b>
Golden shiner	2	0	<b>2</b>
Shorthead redhorse	0	1	<b>1</b>
Channel catfish	80	193	<b>273</b>
Flathead catfish	11	16	<b>27</b>
Banded killifish	0	1	<b>1</b>
Rock bass	21	57	<b>78</b>
Green sunfish	12	22	<b>34</b>
Pumpkinseed	1	4	<b>5</b>
Bluegill	1,834	4,880	<b>6,714</b>
Smallmouth bass	1	3	<b>4</b>
Largemouth bass	5	17	<b>22</b>
White crappie	1	6	<b>7</b>
Black crappie	0	2	<b>2</b>
Tessellated darter	8	5	<b>13</b>
Greenside darter	0	1	<b>1</b>
Yellow perch	0	1	<b>1</b>
Logperch	0	1	<b>1</b>
Crayfish	18	19	<b>37</b>
<b>TOTAL</b>	<b>2,700</b>	<b>6,523</b>	<b>9,223</b>

**Table 8. Number of juvenile American shad collected during intake screen sampling by unit at Peach Bottom atomic Power Station, 28 October to 4 December, 2009.**

<b>Date</b>	<b>Unit 2</b>	<b>Unit 3</b>	<b>Total</b>
28 Oct	1(Adult)*	4	<b>4</b>
11 Nov	1	0	<b>1</b>
<b><i>TOTAL</i></b>	<b>1</b>	<b>4</b>	<b>5</b>

\*Adult Am. Shad not counted as part of the juvenile Am. Shad count.

**Table 9. Species and number of fish collected during cooling water intake sampling at Conowingo Dam in Fall, 2009.**

<b>Species</b>	<b>Francis Units (7)</b>	<b>Kaplan Units (4)</b>	<b>Total</b>
American shad	4	0	<b>4</b>
Gizzard shad	1,533	2,934	<b>4,467</b>
Alewife	1	0	<b>2</b>
Comely shiner	13	6	<b>19</b>
Channel catfish	7	0	<b>7</b>
Spotfin shiner	13	4	<b>17</b>
Bluegill	6	6	<b>12</b>
Walleye	1	0	<b>1</b>
Shield darter	0	1	<b>1</b>
<b>TOTAL</b>	<b>1,578</b>	<b>2,951</b>	<b>4,530</b>

**Table 10. Number of juvenile American shad collected during cooling water intake strainer sampling at Conowingo Dam in Fall, 2009**

<b>Date</b>	<b>Francis Units (7)</b>	<b>Kaplan Units (4)</b>	<b>Total</b>
26 Oct	2	0	2
02 Nov	2*	0	2
<b><i>TOTAL</i></b>	<b><i>4</i></b>	<b><i>0</i></b>	<b><i>4</i></b>

\* Both juvenile shad collected on this day were decapitated and not provided to PFBC for analysis.

**Table 11. Catch of juvenile American shad by location from the upper Chesapeake Bay during the 2009 Maryland DNR juvenile finfish haul seine survey.**

<b>Permanent Sites</b>	<b>Round 1</b>	<b>Round 2</b>	<b>Round 3</b>	<b>Totals</b>
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	1
WELCH PT.	0	0	0	0
HYLAND PT.	0	0	0	1
<b>Total</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2</b>

<b>Auxiliary sites</b>	<b>Round 1</b>	<b>Round 2</b>	<b>Round 3</b>	<b>Totals</b>
CARPENTER PT	0	0	0	0
POPLAR PT	no haul	no haul	no haul	
PLUM PT	9	3	0	12
SPOIL ISLAND	0	0	0	0
TYDINGS ESTATE	0	0	0	0
TOLCHESTER	0	0	0	0
<b>Total</b>	<b>9</b>	<b>3</b>	<b>0</b>	<b>12</b>

Table 12. Analysis of juvenile American shad otoliths collected in the Susquehanna River, 2009.

Collection Site	Coll. Date	Immersion marks							Conodoguinet or Conoy Cr. (mouth)	Bald Eagle Cr.	Total Hatchery	Total Wild	Total Processed	Total Collected
		Day 3,9,12,15,18,21, 24 or 26 or 27	Days 3,6,9,15	Days 3,6,9,12,15	Days 3,6,12,18, 21	Days 3,9,12,15,18, 21	Days 3,6,9	Days 3,7						
		Conodoguinet	N. Br. Susq. (PA)	W. Br. Susq.	W. Br. Susq.	W. Br. Susq.								
<b>Peach Bottom Impingement</b>	10/28/09	0	0	2.7	0.0	1.3	0	0	4	0	3	4		
	11/11/09	0	0	1.0	0.0	0.0	0	0	1	0	1	1		
<b>Conowingo Strainers</b>	10/26/09	0	0	2.0	0.0	0.0	0	0	2	0	2	2		
<b>Total</b>		0	0	5.7	0.0	1.3	0	0	7	**	0	**	6	7
<b>Percent</b>		0%	0%	81%	0%	19%	0%	0%	100%	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.