JOB III. AMERICAN SHAD HATCHERY OPERATIONS, 2009

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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 Pennsylvania 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 2009 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

Adult pre-spawn hickory shad were collected by electrofishing at the mouth of Deer Creek. A total of 11.5 million hickory shad eggs (30.3 L) were received in seven shipments from tank-spawning operations at Conowingo Dam (Table 1). Some 9.7 million (85%) of the hickory shad eggs were viable. Based on the results of tests in 2008 (Hendricks 2009) hickory shad were spawned without the use of hormone injections.

American shad

A total of 15.2 million American shad eggs (282 L) were received in 37 shipments in 2009 (Table 1). This was the lowest quantity of eggs received since 1996 (Table 2, Figure 1). Overall American shad egg viability (which we define as the percentage which ultimately hatches) was 25%.

Fifteen Potomac River egg shipments (6.4 million eggs) were received from April 14 to May 19, 2009. Overall viability was 30%. This is the fewest eggs collected from the Potomac since 2006, the first year of egg collection on that river. Egg collections were hampered by unstable weather and competition with other shad egg collectors at that site.

Delaware River egg shipments were received from May 12 to June 4. A total of 12 shipments were received (3.0 million eggs) with a viability of 20%. This is the fourth lowest Delaware River egg-take since 1988 (Table 4, Figure 1). Unstable weather, frequent rains and high water hampered egg collections on the Delaware.

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. In most trials, shad were injected with hormones and allowed to spawn naturally. Two trials were experimental controls in which shad were not injected with hormones. Both controls were unsuccessful at producing eggs. The tank-spawn array at Conowingo uses water pumped directly from the river and is subject to natural fluctuations in water temperature. Ability to control temperature in the tank (gradual warming to optimal temperature) is thought to be critical for successful tank-spawning without hormones (Jeff Evans, NC Wildlife Resource Commission, personal communication).

In hormone-injected trials, 5.9 million eggs, in 10 shipments, were delivered to the Van Dyke Hatchery, with a viability of 23%. This has become a consistent source of eggs for the restoration program, but viability has been low, ranging from 9% to 33%.

No eggs were collected from the Hudson River in 2009 due to concerns over

declines in the Hudson River stock. The loss of the Hudson River as an egg source is unfortunate because of its consistent production of high quality eggs. Egg production from the Potomac, Delaware and Susquehanna Rivers has been consistently low over the last several years and it has become apparent that additional or expanded sources of eggs will be required to meet the goal of 10-15 million larvae stocked.

SURVIVAL

Survival of individual tanks followed patterns similar to those observed in the past in that the majority of the tanks experienced their highest mortality after nine days of age (Figure 2). Overall survival of American shad larvae was 81% compared to a range of 19% to 94% for the period 1984 through 2008. No tanks suffered complete mortality. The fluidized bed system installed in 2008 worked extremely well and pH of the fish culture water ranged from 6.58 to 7.85 with a mean of 7.35. Daily monitoring of gas saturation and adjustment of the oxygen injection system maintained nitrogen, oxygen and total gas saturation at acceptable levels. Oxygen saturation averaged 101.0% with a maximum of 105.7%. Nitrogen saturation averaged 100.9% with a maximum of 103.1%. Total gas saturation averaged 101.3% with a maximum of 102.9%. As a result, no incidents of gas bubble disease occurred. Larvae stocked in 2009 appeared more active and robust than in previous years.

Tanks with higher than normal mortalities (Figure 2) were generally associated with high bacterial incidence later in the rearing season accompanied by longer residency in the hatchery. High, muddy water resulted in delayed stocking and required holding the

larvae in the hatchery until river conditions abated. The Juniata River has been the stocking site of choice since stocking began in 1976 due to its proximity to the hatchery. For the first time in the history of the program, no hatchery larvae were stocked in the Juniata River due to high turbidity during the entire fish culture season. The mortality issues experienced in 2009 were minor based on the overall survival of 81% compared to an average of 64% since hatchery operations began (Table 2).

LARVAL PRODUCTION

Hickory shad larvae (1.8 million) were stocked in the PA waters of Octoraro Creek below Octoraro Reservoir. Some 5.8 million hickory shad were also stocked in the Delaware River basin in Pennypack Creek (3.8 million) and Ridley Creek (2.0 million).

Production and stocking of American shad larvae, summarized in Tables 2, 3, and 4, totaled 3.1 million. A total of 484 thousand was released in Conodoguinet Creek, 487 thousand in the Susquehanna River at the mouth of Conodoguinet Creek, 17 thousand at the mouth of Conoy Creek (below York Haven Dam), 455 thousand in the North Branch Susquehanna River in Pennsylvania, and 1.3 million in the West Branch Susquehanna River. Due to the lack of certification that the larvae were VHS free, no larvae were stocked in the Potomac River or New York waters of the Susquehanna River. Large numbers of larvae were stocked in the West Branch because the Juniata River was high and turbid, but the West Branch was above normal levels but clear. Larvae stocked at the mouth of Conodoguinet Creek and the mouth of Conoy Creek were stocked in conjunction with shad presentations for canoe trip participants.

Delaware River egg collections were poor due to high water and unstable weather conditions. Eggs collected from the Delaware River were not sufficient to meet the goals for stocking larvae in the Delaware River Basin. Larvae were stocked in the Lehigh River (211 thousand), the Schuylkill River (162thousand). No larvae were stocked in the Delaware River.

TETRACYCLINE MARKING

All American and hickory shad larvae stocked received marks produced by immersion in tetracycline (Table 6). All hickory shad larvae were marked with 512-ppm oxytetracycline hydrochloride for 4h duration and given a single mark on days 1 or 2. Immersion marks for American shad were administered by 4h bath treatments in 256-ppm.

All American shad larvae were marked according to stocking site and/or egg source (Table 6). Some 499 thousand larvae received marks on days 3,9,12,15,18 and 21 and were stocked in the West Branch Susquehanna River. Some 103 thousand larvae marks on days 3,6,12,18 and 21 and were also stocked in the West Branch Susquehanna River. High water in the delayed stocking for 485 thousand larvae which were given an extra mark while they were waiting to be stocked. These larvae were stocked in Conodoguinet Creek. These sequences will not be repeated, thus, when these larvae return as adults, they will be known age (see Table 7). Some 487 thousand larvae were marked on days 3,6 and 9 and stocked at the mouth of Conodoguinet Creek.

Some 17 thousand larvae were also marked on days 3,6, and 9 and stocked at the mouth of Conoy Creek. Some 455 thousand larvae received marks on days 3,6,9,15 and were stocked in the North branch Susquehanna River. Larvae stocked in the Lehigh River received marks on days 9,12,15 (211 thousand) Some 162 thousand larvae were marked on days 3,6,9,12 and stocked in the Schuylkill River.

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.

All fish examined exhibited marks, however observed marks did not necessarily conform to the marking protocol (Table 6). Digital photographs have been archived from representative samples of the marks detected for future reference. These will assist in identifying the origin of marks detected in out-migrating juveniles and returning adults from the 2009 cohort.

No hickory shad larvae survived raceway culture, so no analysis of mark retention was possible. Other groups that did not survive raceway culture included: West Branch (3,9,12,15,18,21), Conodoguinet Creek (3,9,12,15,18, 21,27 and 3,9,12,15,18,21,26), and Conodoguinet and Conoy Creeks (3,6,9). Raceway culture was hampered by high pH from the warming pond source and low temperature when the source was converted to well water. Raceway culture in 2010 will utilize warming pond water regardless of pH.

Groups which exhibited the intended mark in 100% of the specimens examined included the West Branch (3,6,12,18,21) and (3,6,9,12,15), Conodoguinet Creek (3,9,12,15,18,21,24), and the North Branch in Pennsylvania (3,6,9,15). Unfortunately sample sizes were small in two of these groups due to poor raceway survival (Table 6).

Approximately 10,000 thousand OTC marked larvae were provided to the USFWS, Northeast Fishery Center at Lamar for experimental marking with calcien. These fish were marked with OTC on day 3 and calcien on day 7. After grow-out and mark evaluation, 300 fingerlings were stocked in Bald Eagle Creek and fifty were provided to the PFBC for tag retention analysis. Thirty-two of fifty (64%) of the specimens evaluated for marks exhibited both marks. The remaining eighteen exhibited only the OTC mark. The calcien mark, when present, could be distinguished from the OTC mark by its apple-green color, compared to an orange-yellow color for the OTC mark.

SUMMARY

Seven shipments of hickory shad eggs (11.5 million eggs) were received at Van Dyke in 2009. Egg viability was 85% and 7.6 million hickory shad larvae were stocked in Octoraro Creek and in Delaware River tributaries, Pennypack Creek and Ridley Creek. Hickory shad brood did not receive hormone injections to induce egg maturation.

A total of 37 shipments of American shad eggs (15 million eggs) was received at Van Dyke in 2009. Total egg viability was 25% and survival of viable eggs to stocking was 81%, resulting in production of 3.1 million larvae. Larvae were stocked in the West

Branch Susquehanna River (1.3 million), the North Branch Susquehanna River in Pennsylvania (455 thousand), Conodoguinet Creek (485 thousand), the mouth of Conodoguinet Creek (487 thousand), and the mouth of Conoy Creek (17 thousand). Delaware river source larvae were stocked in the Lehigh River (211 thousand), and the Schuylkill River (162 thousand). No larvae were stocked in the Juniata River due to turbidity. No larvae were stocked in the Delaware River because our stocking goals in the Lehigh and Schuylkill Rivers were not met.

Overall survival of larvae was 81%. No major mortality occurred due to disruption of flow. Some mortality occurred in a number of tanks associated with bacterial infestation, but this was a minor problem late in the growing season. Installation of a fluidized bed system in 2008 and closer monitoring of the oxygen injection system resulted in pH and gas saturation levels that contributed to high survival.

All American and hickory shad larvae cultured at Van Dyke were marked by 4-hour immersion in oxytetracycline. Marks for American shad were assigned based on release site and/or egg source river. Shad examined for mark retention generally exhibited the intended mark except for fry stocked in the Lehigh River which occasionally (7%) exhibited a double mark instead of the intended triple mark. Several groups of fry did not survive raceway culture and could not be examined for marks. An experimental calcien mark applied at the USFWS Northeast Fishery Center at Lamar was visible in 64% of the specimens examined.

RECOMMENDATIONS FOR 2010

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. Use MSXXX jars preferentially to promote egg layering and maintain good egg survival.
8. Continue to collect American shad eggs from the Potomac River as an additional source of out-of-basin eggs.
9. Continue to develop a reference collection of scales and otoliths from known age American shad by marking according to year stocked (Table 7). Utilize uniquely marked larvae from the Potomac River egg source, stocked in the Juniata or Susquehanna Rivers.
10. Mark hickory shad at 512ppm OTC.
11. Continue using Pfizer Terramycin 343 (now FDA approved) for marking alosines.
12. Continue to utilize a fluidized bed system, using limestone sand to buffer the Van Dyke source water, neutralize the pH and reduce dissolved aluminum.

13. Continue to record pH, hardness and alkalinity on a regular basis to monitor fish culture water quality.
14. Continue to utilize additional packed column de-gassers to reduce the need for oxygen injection.
15. Continue to measure and record oxygen and nitrogen saturation on a daily basis. Use the oxygen injection system only when needed and monitor oxygen saturation and larval condition when the system is in use.
16. Mark all tanks of larvae beginning at 11:00AM, to ensure consistency in daily mark application.
17. Consider other options for hickory shad restoration, including direct stocking of eggs or stocking of pre-spawn adults, based on the absence of adult hickory shad in extensive collections conducted in 2009 by the Philadelphia Water Department.
18. Investigate the potential of increasing egg production at Conowingo Dam by constructing a new tank-spawn facility with the capability of controlling temperatures in order to tank-spawn without the use of hormone injections.
19. Rear raceway cultured juvenile shad in warming pond water regardless of pH.

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Figure 1. American shad eggs incubated at Van Dyke, 1985-2009.

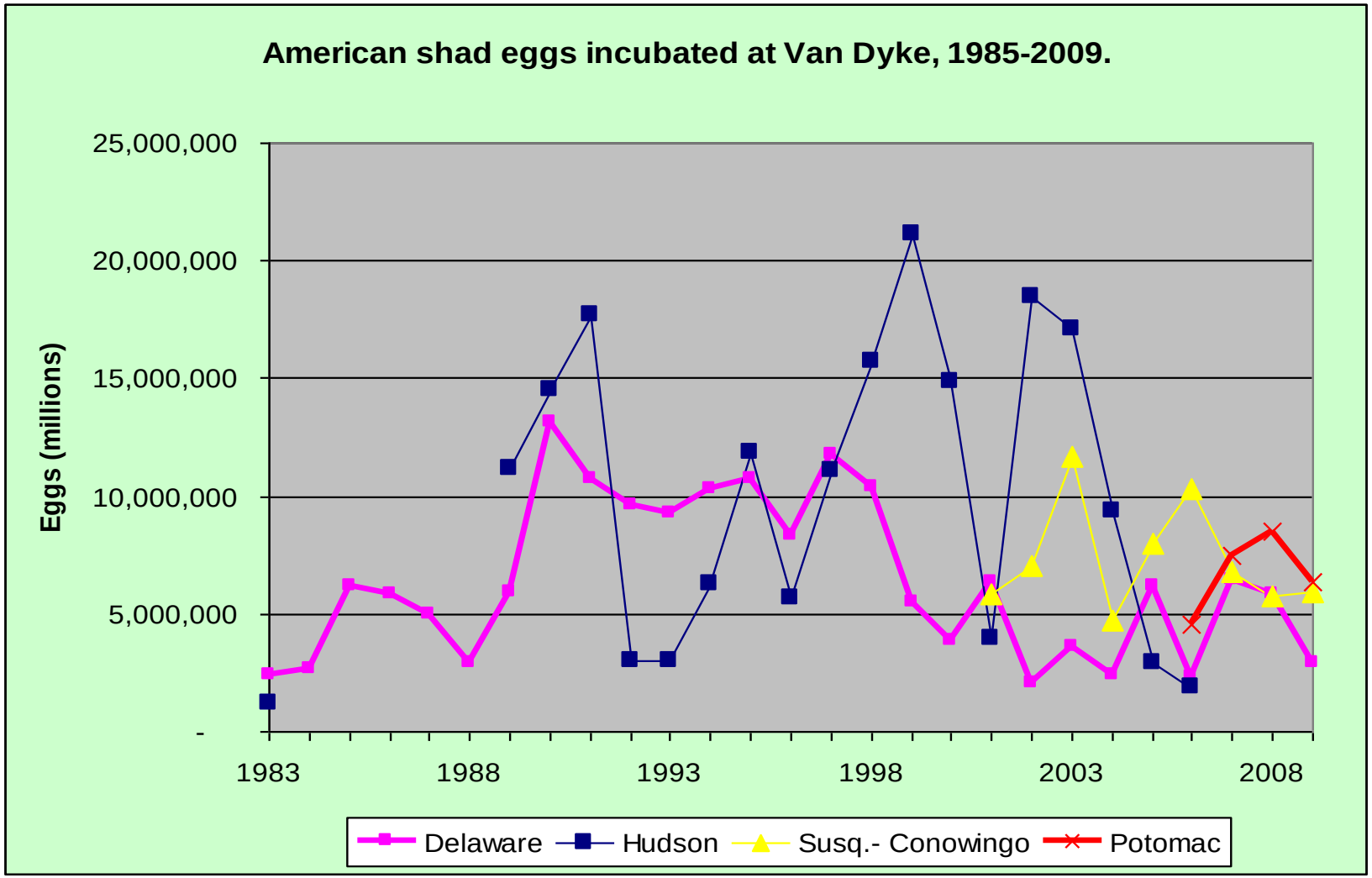

Figure 2. Survival of American shad larvae, by tank, Van Dyke, 2009.

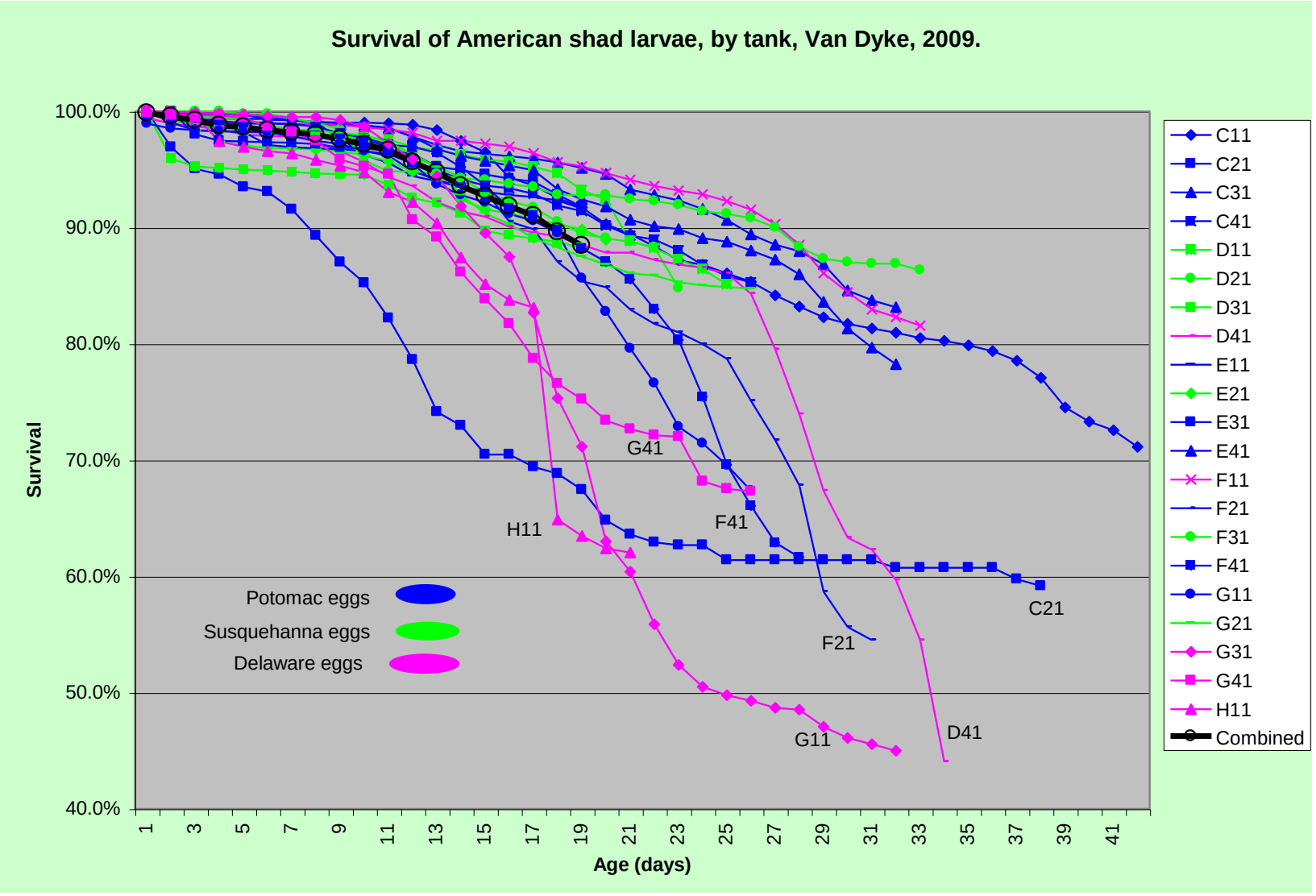

Table 1. Egg shipments received at Van Dyke, 2009.

No.	Species	River	Date Spawned	Date Received	Volume (L)	Eggs	Viable Eggs	Percent Viable
1	American shad	Potomac	4/13/09	4/14/09	5.2	200,559	46,807	23.3%
2	American shad	Potomac	4/14/09	4/14/09	5.9	216,106	73,017	33.8%
3	American shad	Potomac	4/15/09	4/16/09	7.5	274,711	25,179	9.2%
4	Hickory shad	Susquehanna	4/15/09	4/16/09	4.0	2,224,308	1,918,466	86.3%
5	American shad	Potomac	4/16/09	4/17/09	6.2	220,071	13,412	6.1%
6	Hickory shad	Susquehanna	4/18/09	4/18/09	12.1	4,261,351	3,780,668	88.7%
7	Hickory shad	Susquehanna	4/19/09	4/19/09	3.7	1,296,494	1,161,884	89.6%
8	Hickory shad	Susquehanna	4/20/09	4/20/09	2.1	683,979	455,613	66.6%
9	American shad	Potomac	4/21/09	4/22/09	6.7	242,861	41,543	17.1%
10	American shad	Potomac	4/22/09	4/23/09	3.7	141,249	29,479	20.9%
11	Hickory shad	Susquehanna	4/23/09	4/23/09	3.4	1,373,657	1,091,222	79.4%
12	Hickory Shad	Susquehanna	4/24/09	4/24/09	3.2	941,733	720,705	76.5%
13	Hickory shad	Susquehanna	4/24/09	4/25/09	1.9	698,651	613,916	87.9%
14	American shad	Potomac	4/26/09	4/27/09	6.5	296,917	0	0.0%
15	American shad	Potomac	4/27/09	4/28/09	19.5	1,064,778	2,461	0.2%
16	American shad	Potomac	4/28/09	4/29/09	12.0	697,968	47,390	6.8%
17	American shad	Potomac	4/29/09	4/30/09	8.5	334,597	139,393	41.7%
18	American Shad	Susquehanna	5/2/09	5/2/09	7.5	476,350	233,630	49.0%
19	American Shad	Susquehanna	5/3/09	5/3/09	9.0	513,428	37,898	7.4%
20	American shad	Susquehanna	5/5/09	5/6/09	14.2	847,498	86,166	10.2%
21	American Shad	Susquehanna	5/9/09	5/9/09	6.5	412,837	109,698	26.6%
22	American shad	Delaware	5/11/09	5/12/09	1.8	64,566	2,144	3.3%
23	American shad	Potomac	5/12/09	5/13/09	15.0	819,060	497,034	60.7%
24	American shad	Delaware	5/12/09	5/13/09	4.9	198,830	50,403	25.3%
25	American shad	Susquehanna	5/12/09	5/13/09	8.5	478,477	25,583	5.3%
26	American shad	Potomac	5/13/09	5/14/09	17.3	743,099	451,651	60.8%
27	American shad	Delaware	5/13/09	5/14/09	5.0	202,888	90,147	44.4%
28	American shad	Potomac	5/14/09	5/15/09	9.4	389,160	204,117	52.5%
29	American shad	Susquehanna	5/15/09	5/15/09	13.1	800,367	277,736	34.7%
30	American shad	Delaware	5/14/09	5/15/09	2.7	188,367	79,998	42.5%
31	American Shad	Susquehanna	5/17/09	5/17/09	8.0	486,396	20,006	4.1%
32	American shad	Potomac	5/17/08	5/18/09	5.0	232,847	101,429	43.6%
33	American shad	Potomac	5/18/09	5/19/09	9.9	506,803	212,589	41.9%
34	American shad	Susquehanna	5/20/09	5/20/09	11.0	710,832	196,345	27.6%
35	American shad	Delaware	5/20/09	5/21/09	1.3	59,383	6,598	11.1%
36	American shad	Delaware	5/21/09	5/22/09	9.8	381,860	134,241	35.2%
37	American Shad	Susquehanna	5/22/09	5/22/09	11.3	705,327	300,393	42.6%
38	American Shad	Susquehanna	5/24/09	5/24/09	7.6	453,993	79,022	17.4%
39	American shad	Delaware	5/25/09	5/26/06	2.9	190,651	15,386	8.1%
40	American shad	Delaware	5/26/09	5/27/09	8.1	887,699	115,263	13.0%
41	American shad	Delaware	5/27/09	5/28/09	2.7	253,215	39,230	15.5%
42	American shad	Delaware	5/31/09	6/1/09	0.8	25,511	1,481	5.8%
43	American shad	Delaware	6/1/09	6/2/09	3.7	275,878	26,274	9.5%
44	American shad	Delaware	6/3/09	6/4/09	3.4	231,273	26,300	11.4%
Totals			No. of shipments					
	American shad	Potomac	15		138.3	6,380,784	1,885,500	29.5%
		Delaware	12		47.1	2,960,122	587,466	19.8%
		Susquehanna	10		96.7	5,885,504	1,366,478	23.2%
		Grand total	**37**		**282.1**	**15,226,409**	**3,839,443**	**25.2%**
	Hickory shad	**Susquehanna**	**7**		**30.3**	**11,480,173**	**9,742,474**	**84.9%**

Table 2. Annual summary of American shad production, 1976-2009.

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 Fingerling 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
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
2005	372	17.1	36.6	6.0	5,208		1	5,209	0.30	0.87
2006	394	19.0	35.2	6.7	4,945		-	4,945	0.26	0.74
2007	404	20.7	27.7	5.8	2,509		-	2,509	0.12	0.43
2008	441	20.1	28.3	5.7	4,020		-	4,020	0.20	0.71
2009	282	15.2	25.2	3.8	3,073		-	3,073	0.20	0.81
*Includes fry reared at Manning Hatchery.							**Total**	**254,968**		
					Total since 1985 (OTC marked)			**223,571**		

Table 3. American shad eggs used in Pennsylvania's shad restoration program, by egg source.

Year	Hudson Gill Net	Delaware Gill Net	Susquehanna Conowingo Tank Spawn	Susquehanna Lapidum Gill Net	Susquehanna Muddy Run Gill Net	Susquehanna Lamar Tank Spawn	Connecticut Gill Net	Pamunkey Gill Net	Mattaponi Gill Net	James Gill Net	Savannah Gill Net	Columbia Gill Net	Potomac Gill Net	Total
1971				8.42										8.42
1972				7.10										7.10
1973				4.74			4.30	8.45	6.48				34.64	58.61
1974							0.53	9.75	6.80	19.20		8.18	5.56	50.02
1975								1.88		7.15		18.42	5.70	33.15
1976		4.10										54.80		58.90
1977							0.35	4.40	0.57	3.42		8.90		17.64
1978								6.90		10.11		0.00		17.01
1979								3.17		4.99		0.00		8.16
1980								6.73		6.83		0.00		13.56
1981								4.58		1.26		5.78		11.62
1982								2.03		1.25		22.57		25.85
1983	1.17	2.40						5.49		5.91		19.51		34.48
1984		2.64						9.83		0.74		27.88		41.09
1985		6.16						5.28		2.05		12.06		25.55
1986		5.86						5.62		1.07		39.97		52.52
1987		5.01						4.35		0.11		23.53		33.00
1988		2.91						1.92		0.05		26.92		31.79
1989	11.18	5.96						1.91		0.53		23.10		42.68
1990	14.53	13.15				0.33		0.48			0.12			28.61
1991	17.66	10.75				0.30	1.10							29.80
1992	3.00	9.60					5.71			0.17				18.49
1993	2.97	9.30					7.45	1.78						21.50
1994	6.29	10.27					4.09	0.53	0.03					21.22
1995	11.85	10.75												22.61
1996	5.69	8.31				0.41								14.41
1997	11.08	11.76												22.84
1998	15.68	10.38				1.66								27.72
1999	21.10	5.49												26.59
2000	14.88	3.83												18.71
2001	3.92	6.35	5.81			5.05								21.13
2002	18.51	2.04	7.08			7.99								35.62
2003	17.12	3.61	11.72	0.56	0.02									33.04
2004	9.39	2.41	4.74	0.75										17.29
2005	2.92	6.21	8.00										0.00	17.14
2006	1.86	2.33	10.28										4.51	18.98
2007	0.00	6.46	6.77										7.49	20.72
2008		5.87	5.75										8.50	20.12
2009		2.96	5.89										6.38	15.23
Total	190.81	176.87	66.04	21.57	0.02	15.74	23.53	85.08	13.88	64.84	0.12	291.62	72.78	######

Table 4. American and hickory shad stocking, 2009.

Date	Tank	Species	Number	Location	OTC mark (days)	Origin	Age	Size
4/23/09	A1 1	Hickory shad	1,606,296	Octoraro Cr.	2	Susquehanna	3	Fry
4/25/09	A2 1	Hickory shad	892,556	Pennypack/Ridley Creeks	2	Susquehanna	3	Fry
4/25/09	A3 1	Hickory shad	1,357,208	Pennypack/Ridley Creeks	2	Susquehanna	3	Fry
4/25/09	A4 1	Hickory shad	633,443	Pennypack/Ridley Creeks	2	Susquehanna	3	Fry
4/27/09	B1 1	Hickory shad	872,515	Pennypack Creek	1	Susquehanna	2	Fry
4/26/09	B2 1	Hickory shad	217,186	Octoraro Cr.	1	Susquehanna	2	Fry
4/30/09	B3 1	Hickory shad	1,007,720	Pennypack Creek	1	Susquehanna	2	Fry
5/1/09	B4 1	Hickory shad	528,463	Pennypack/Ridley Creeks	1	Susquehanna	2	Fry
5/1/09	A1 2	Hickory shad	489,366	Pennypack/Ridley Creeks	1	Susquehanna	2	Fry
6/1/09	C1 1	American shad	103,169	West Branch Susquehanna River	3,6,12,18,21	Potomac	39	Fry
6/1/09	C2 1	American shad	7,935	West Branch Susquehanna River	3,9,12,15,18,21	Potomac	37	Fry
6/1/09	C3 1	American shad	100,462	West Branch Susquehanna River	3,9,12,15,18,21	Potomac	32	Fry
6/1/09	C4 1	American shad	159,981	West Branch Susquehanna River	3,9,12,15,18,21	Potomac	24	Fry
6/2/09	D1 1	American shad	231,107	West Branch Susquehanna River	3,9,12,15,18,21	Susquehanna	24	Fry
6/3/09	D2 1	American shad	73,064	West Branch Susquehanna River	3,6,9,12,15	Susquehanna	22	Fry
6/3/09	D3 1	American shad	95,415	West Branch Susquehanna River	3,6,9,12,15	Susquehanna	19	Fry
6/23/09	D4 1	American shad	23,155	Schuylkill River	3,6,9,12	Delaware	33	Fry
6/8/09	E1 1	American shad	455,432	North Branch Susquehanna River (PA)	3,6,9,15	Potomac	18	Fry
6/9/09	E2 1	American shad	269,799	West Branch Susquehanna River	3,6,9,12,15	Susquehanna	17	Fry
6/9/09	E3 1	American shad	215,146	West Branch Susquehanna River	3,6,9,12,15	Potomac	18	Fry
6/22/09	E4 1	American shad	169,985	Conodoguinet Creek	3,9,12,15,18,21,27	Potomac	31	Fry
6/23/09	F1 1	American shad	138,783	Schuylkill River	3,6,9,12	Delaware	32	Fry
6/22/09	F2 1	American shad	111,284	Conodoguinet Creek	3,9,12,15,18,21,26	Potomac	30	Fry
6/26/09	F3 1	American shad	17,274	Mouth of Conoy Creek	3,6,9	Susquehanna	32	Fry
6/22/09	F4 1	American shad	62,517	Conodoguinet Creek	3,9,12,15,18,21,24	Potomac	27	Fry
6/22/09	G1 1	American shad	141,118	Conodoguinet Creek	3,9,12,15,18,21,24	Potomac	26	Fry
6/24/09	G2 1	American shad	487,268	Conodoguinet Cr. Mouth	3,6,9	Susquehanna	27	Fry
6/29/09	G3 1	American shad	63,391	Lehigh River	9,12,15	Delaware	30	Fry
6/29/09	G4 1	American shad	113,656	Lehigh River	9,12,15	Delaware	26	Fry
6/29/09	H1 1	American shad	33,537	Lehigh River	9,12,15	Delaware	20	Fry

Table 5. Summary of stocking of juvenile Alosines from the Van Dyke Hatchery, 2009.

	Site		Fry
American shad Releases	Millerstown (Greenwood)		0
	Millerstown (Rt. 17 Bridge)		0
	Miller's Canoe Rental		0
	Thompsontown		0
	Muskrat Springs	Note: Juniata River	0
	Mexico	muddy all season, no	0
	Mifflin	shad larvae stocked	0
	Treaster's Exxon		0
	Huntingdon		0
	Warrior Ridge Dam		0
	Tuscarora Creek		0
	Juniata River Subtotal		0
	Clemson Island		0
	Montgomery Ferry		0
	Millersburg Ferry		0
	Liverpool		0
	Mahantango		0
	Conodoguinet Creek		484,905
	Mouth of Conodoguinet Creek		487,268
	Mouth of Conoy Creek		17,274
	Conestoga River		0
	Swatara Creek		0
	West Conewago Creek		0
	North Branch Susquehanna River (PA)		455,432
	West Banch Susquehanna River		1,256,078
	Chemung River		0
	North Branch Susquehanna River (NY)		0
	Susquehanna River Basin Subtotal		**2,700,956**
	Delaware River		0
	Schuylkill River		161,938
	Lehigh River		210,584
	Nanticoke River		0
	Potomac River		0
	Raritan River		0
	Total American shad		**3,073,478**
Hickory shad releases	Octoraro Creek		1,823,481
	Susquehanna River Basin Subtotal		1,823,481
	Pennypack Creek		3,830,753
	Ridley Creek		1,950,518
	Delaware River Basin Subtotal		5,781,271
	Total Hickory shad		**7,604,752**

Table 6. Summary of marked Alosines stocked in Pennsylvania, 2009.

Number	Size	Immersion mark (days)	Stocking Location	Egg Source	Immersion mark	Immersion Mark Retention (%)	Feed Mark	Feed Mark Retention (%)	Fry Culture
American shad									
499,485	Fry	3,9,12,15,18,21	W. Br. Susq. R.	Potomac	256ppm OTC	N/A	-	-	Van Dyke
103,169	Fry	3,6,12,18,21	W. Br. Susq. R.	Potomac	256ppm OTC	100%*	-	-	Van Dyke
169,985	Fry	3,9,12,15,18,21,27	Conodoguinet Cr.	Potomac	256ppm OTC	N/A	-	-	Van Dyke
111,284	Fry	3,9,12,15,18,21,26	Conodoguinet Cr.	Potomac	256ppm OTC	N/A	-	-	Van Dyke
203,635	Fry	3,9,12,15,18,21,24	Conodoguinet Cr.	Potomac	256ppm OTC	100%	-	-	Van Dyke
1,087,558	Fry	Quintuple, sextuple or septuple tag for known age study							
653,424	Fry	3,6,9,12,15	W. Br. Susq. R.	Susquehanna	256ppm OTC	100%**	-	-	Van Dyke
487,268	Fry	3,6,9	Conodoguinet Cr. (mouth)	Potomac	256ppm OTC	N/A	-	-	Van Dyke
17,274	Fry	3,6,9	Conoy Cr. (mouth)	Potomac	256ppm OTC	N/A	-	-	Van Dyke
455,432	Fry	3,6,9,15	N. Br. Susq. R.(PA)	Potomac	256ppm OTC	100%	-	-	Van Dyke
210,584	Fry	9,12,15	Lehigh R.	Delaware	256ppm OTC	93%***	-	-	Van Dyke
161,938	Fry	3,6,9,12	Schuylkill R.	Delaware	256ppm OTC	100%	-	-	Van Dyke
300	Fing.	3,7****	Bald Eagle Creek	Potomac	256ppm OTC	64%*****	-	-	Van Dyke
Hickory shad									
1,823,481	Fry	2 or 1	Octoraro Cr.	Susquehanna	512ppm OTC	N/A	-	-	Van Dyke
1,950,518	Fry	2 or 1	Ridley Cr.	Susquehanna	512ppm OTC	N/A	-	-	Van Dyke
3,830,753	Fry	2 or 1	Pennypack Cr.	Susquehanna	512ppm OTC	N/A	-	-	Van Dyke
7,604,752	Fry	Hickory shad total							

N/A- None analyzed because none survived raceway culture.

* Only four specimens analyzed due to poor survival in the raceway.

** Only two specimens analyzed due to poor survival in the raceway.

*** One appeared to have marks at 9 and 12 days, but no day 15 mark, one appeared to have marks at 12 and 15 days but no day 9 mark. Five others ha 15 marks very close together.

**** Day 3 mark was OTC, day 7 was an experimental calcien mark.

***** 32 of 50 (64%) exhibited both tags, the remaining 18 exhibited only the OTC tag.

Table 7. Proposed marking plan for Alosines stocked in Pennsylvania, 2006-2010.

Size	Immersion mark (days)	Immersion mark	Stocking Location	Egg Source	Years
American shad					
Fry	18	256ppm OTC	Juniata/Susq. R.	Potomac	2006
Fry	15,18	256ppm OTC	Juniata/Susq. R.	Potomac	2007
Fry	15,18,21,24	256ppm OTC	Juniata/Susq. R.	Potomac	2008
Fry	3,9,12,15,18,21	256ppm OTC	Juniata/Susq. R.	Potomac	2009
Fry	3,6,12,15,18,21	256ppm OTC	Juniata/Susq. R.	Potomac	2010
Fry	3,6,9	256ppm OTC	Juniata/Susq. R.	Susquehanna	2006-2010
Fry	3,6,9,12,15	256ppm OTC	W. Br. Susq. R.	Potomac	2006-2010
Fry	3,6,12,15	256ppm OTC	Conodoguinet Cr.	Potomac	2006-2010
Fry	3,9,12,15	256ppm OTC	Conestoga R.	Potomac	2006-2010
Fry	3,9,12,15,18	256ppm OTC	W. Conewago Cr.	Potomac	2006-2010
Fry	3,6,9,15,18	256ppm OTC	Swatara Cr.	Potomac	2006-2010
Fry	3,6,9,15	256ppm OTC	N. Br. Susq. R.(PA)	Potomac	2006-2010
Fry	3,6,9,12,18	256ppm OTC	N. Br. Susq. R.(NY)	Potomac	2006-2010
Fry	3,15,18	256ppm OTC	Chemung R. (NY)	Potomac	2006-2010
Fry	9,12,15	256ppm OTC	Lehigh R.	Delaware	2006-2010
Fry	3,6,9,12	256ppm OTC	Schuylkill R.	Delaware	2006-2010
Fry	3,6,12,15,18	256ppm OTC	Del. R. (Smithfield)	Delaware	2006-2010
Fry	3,6	256ppm OTC	Potomac R.	Potomac	2006-2010
Hickory shad					
Fry	3	512ppm OTC	Conowingo Res. /Octoraro Cr.	Susquehanna	2006-2010
Fry	3	512ppm OTC	Delaware River	Susquehanna	2006-2010
Fry	3	512ppm OTC	Ridley Cr.	Susquehanna	2006-2010
Fry	3	512ppm OTC	Pennypack Cr.	Susquehanna	2006-2010