

**REPORT ON HORMONE-INDUCED SPAWNING TESTS
WITH AMERICAN AND HICKORY SHAD AT
CONOWINGO DAM, SPRING 2009**

INTRODUCTION

The Conowingo Dam West Fish Lift was built in 1972 and has been operated annually during the months of April, May and early June. Initially it was an integral part of the anadromous fish restoration effort, which combined the operation of the West Fish Lift, hand sorting of target species and a fleet of transport trucks to carry American shad and other Alosids to upriver release sites. Since the completion of permanent fish lifts at Conowingo Dam (1991), Holtwood and Safe Harbor Dam (1997), and a fish ladder at York Haven Dam (2000), the role of the Conowingo West Fish Lift has changed. Beginning in 2001, the Conowingo West Fish Lift has operated under contract as (1) a source of fishes for special on-site spawning studies to provide the PA Fish and Boat Commission Van Dyke Shad Hatchery with a source of fertilized American shad eggs, (2) provide adult shad for studies conducted by the Maryland Department of Natural Resources at the Manning Hatchery and (3) a source of otoliths and scales from adult American shad to analyze the age structure and origin of returning adult shad. The West Fish Lift when operated 6-8 hours per day and six days per week from late April through early June typically captures 3,000 to 10,000 adult American shad. The majority of these fish are in a pre-spawn condition and based on studies at the USFWS Lamar facility many of these fish could be induced to spawn within several days after injection of hormone implants. The advantage of conducting spawning studies on site at Conowingo Dam rather than at a distant hatchery is the elimination of the stress associated with lengthy transport times.

Hormone induced hickory shad spawning tests began at the Conowingo West Fish lift in 2003 and were conducted annually through 2008. In 2009 hickory shad spawning tests were conducted without the use of hormones. The West Fish Lift captures few, if any, hickory shad in a typical

year. Anglers however are quite successful in catching hickory shad at Shures Landing in Conowingo Fisherman's Park and at the mouth of Deer Creek beginning in early April. Maryland Department of Natural Resources and USFWS biologists have also been successful in collecting hickory shad with boat mounted electrofishing gear in the Rock Run area, upstream from the Lapidum Boat Launch.

METHODS AND MATERIALS

The methods used to conduct the hormone induced spawning tests at the Conowingo West Fish lift in 2009 were generally similar to those used in the past eight years with the following exceptions: The 2009 spawning tests with hickory shad were conducted without hormone implants or injections. This decision was based on the experience gained from the 2008 tests with hickory shad when the control groups produced almost as many fertilized eggs as the treatment groups. The 2008 tests with un-injected American shad produced very few eggs thus the 2009 study plan for American shad spawning tests included hormone injections and was submitted to the U.S. Department of Interior Fish and Wildlife Service Aquatic Animal Drug Approval Partnership Program, Bozeman MT, for approval. The approved American shad study plan was assigned Study Number 11-375-09-7. The study protocols for the use of Salmon Gonadotropin-Releasing Hormone Analog (sGnRH_a) under the investigational new animal drug (INAD) #11-375 required the use of hormone pellets manufactured solely by Syndel Industries Inc. and the inclusion of control fish in the testing schedule. The smallest dose of sGnRH_a available from Syndel was 75ug per pellet and all treatment fish received this dose in the 2009 tests. Other requirements under this INAD included keeping detailed records of hormone inventory, collecting length and weight data on test fish and reporting results to Bozeman MT.

Cooperating anglers at the mouth of Deer Creek were a minor source of hickory shad for the 2009 tests. A small number of hickory shad were caught by hook and line at the Lapidum Launch. The

Maryland DNR electrofishing effort near the Lapidum Boat Launch provided the major portion of the hickory shad for the four hickory shad spawning tests in 2009. The hickory shad were transported 5.6 mi (Deer Creek) or 7.1 mi (Lapidum) to Conowingo Dam by a Pennsylvania Fish and Boat Commission (PFBC) pick-up truck outfitted with an oxygenated circular tank. Aquashade, a harmless blue pigment was added to the tank to reduce stress on the fish. The transport tank capacity was about 40 fish per trip. A total of 399 hickory shad was transported between 4/13 and 4/22. Each test was started on the same day that the fish were caught. No length or weight data was collected from hickory shad prior to placement into the spawning tanks. A 3:2 (M/F) sex ratio was the goal for hickory shad tests and that ratio was never attained in 2009. Females comprised less than 20% of the test fish in two tests and about 30% in the other two tests. Spawning tests were conducted in a 10 ft diameter or 12 ft diameter fiberglass tank. These two tanks were assembled on-site at the West Fish Lift in early April and plumbed in a configuration identical to that used since 2001 (Figure 1). Both tanks were supplied with approximately 40 gpm of river water through a wall mounted 2-inch fitting. A screened 4-inch PVC drainpipe in the bottom of each tank provided the only exit for the demersal shad eggs and water from the tank. The water level in both spawning tanks was maintained by an external standpipe that also provided a source of water for the rectangular 72 by 36 by 16 inch raised egg collection tank. The calculated volumes for the 10 ft and 12 ft tanks were 6,400 and 9,200 liters respectively. An egg sock fastened to the discharge from the spawning tank prevented the eggs from exiting the egg tank via the standpipe drain that maintained the water level in the egg tank. Individual tests lasted 6 to 8 days and were terminated when egg production declined or ceased. Oxygen and temperature were monitored daily in the spawning tanks during each test. The egg sock was examined daily during each spawning test. Following the initial pulse of egg production (usually 48 hours after hormone injection) the eggs were washed out of the sock into a 10 gal plastic bucket. The eggs were then sieved with a colander with 0.25 in holes to remove

scales and other debris. After sieving, the eggs were transferred to a framed nylon net suspended in the egg tank. A No. 20 standard testing sieve was used to transfer the washed eggs from the nylon net into a graduated 2 liter measuring cup. Volume measurements in the field were approximations. The final volume and viability determinations for all shipments were made at the PFBC Van Dyke Hatchery. The packaging of eggs for shipment followed well-established techniques. Up to five liters of water hardened eggs were mixed with 5 liters of river water in double plastic bags. Pure oxygen was introduced into the inner bag before being sealed with tape or rubber band. The bags were placed into marked insulated shipping containers and driven to the Van Dyke Hatchery by PFBC or Normandeau personnel; eggs were always driven to the hatchery on the same day they were collected. Since no hormone implants were used on hickory shad this year, all fish that survived to the end of the test were released to the river. No attempts were made to hand strip shad following their removal from the spawning tanks. When the fourth test group of Hickory shad was removed from their spawning tank on 4/24 no further hickory shad tests were attempted because the goal of four test groups was met and American shad numbers in the Conowingo tailrace were sufficient to warrant operation of the West Fish Lift and begin spawning tests with American shad.

The Conowingo West Fish Lift was the source of all 994 pre-spawned American shad utilized for the 16 spawning tests conducted at Conowingo Dam in 2009. All fish were measured for fork and total length and a sub-sample (312) of weights was taken prior to placement of fish into the spawning tanks. The equipment, egg collection and shipping methods for the American shad spawning tests at the West Lift were essentially the same as described above for hickory shad except that some American shad were kept in oxygenated holding tanks for up to 2 days while a sufficient number of shad needed to stock a spawning tank was collected. American shad spawning tests began on 4/30 and ended on 5/29. During this interval, 12 treatment and 4 control groups were tested. Test group size (50 adults in 10 ft tank and 75 adults in 12 ft tank) was

adjusted to achieve a similar density of 1 fish per 125 liters of water. A sex ratio of 3 males to 2 females was achieved for almost all test groups.

RESULTS

A total of 30.25 liters of eggs was collected from the four test groups of hickory shad and shipped to the Van Dyke Hatchery in 2009 (Table 1 and Appendix Table A-1). The overall viability of the hickory shad eggs sent to the Van Dyke Hatchery was 85% (Mike Hendricks, personal communication). This is the highest average viability observed since spawning tests with hickory shad began in 2003. The volume of eggs produced per female (0.312 liters) was also the highest observed since 2003 (Figure 2). Water temperature in the spawning tanks ranged from 10.0 to 16.0°C and dissolved oxygen levels ranged from 8.8 to 10.8 ppm during the tests. Adult mortality rate for hickory shad during the 2009 spawning tests was 4.5%. Mortality in past years has ranged from 2.2-22.1% (Table 2).

A total of 16 on-site spawning trials with 994 American shad from April 30th to May 29th produced 98.7 liters of eggs (Table 3 and Appendix Table A-2). Over 96 liters of eggs were shipped to the Van Dyke Hatchery and the remaining 2.0 liters were released into the river below Conowingo Dam. The overall estimated viability of the eggs shipped to Van Dyke was 23.2% (Mike Hendricks, personal communication). The total volume of eggs produced per female in 2009 (0.318 liters) was slightly below the average of 0.325 liter observed for the previous eight years (Figure 3). When adjusted for viability, the volume of viable eggs produced per female in the 2009 tests averaged 0.074 liters (Figure 3). There was a noticeable difference in the average volume of eggs produced between the treatment and control test groups. Test groups that received the hormone treatment produced an average of 8.0 liters of eggs while control groups produced 0 to 2.5 liters per group. Control groups typically didn't produce any eggs until 72 hrs after the fish were placed in the spawning tank and daily egg production was usually less than 2

liters. Treatment fish usually produced the first and largest pulse of eggs after 48 hrs followed by little or no egg production past 72 hrs. Water temperatures and oxygen levels in the spawning tanks were monitored daily and ranged from 17.3 to 23.0°C and 6.0 to 9.0 ppm. The overall mortality rate for adult American shad during the 2009 tests was 15 %. Mortality rates have ranged from 2 to 11.5% in previous years (Table 4). The mortality rate for individual control groups in 2009 ranged from 9 to 64%. The higher control mortalities were probably due to the prolonged holding times (up to 7 days) for control groups.

SUMMARY

The results of the hickory shad spawning tests at Conowingo Dam in 2009 showed a continuation of the high quality levels achieved from 2005 through 2008. The estimated overall egg viability of 84.9% is the highest viability that has been observed in the last six years of hickory shad spawning tests. This year's success with hickory shad egg production without the use of hormone injections indicates that many of the test fish were close to being fully ripe when they were captured.

This was the ninth year of hormone induced American shad spawning tests at the Conowingo West Fish Lift. The overall viability (23%) of the 2009 American shad eggs was noticeably higher than the 9.8% viability recorded last year but still lower than the 33.2% reached in 2001. The cause for this year's improved egg quality for the American shad spawning tests is still unclear. Steady river temperature may have been a factor. Warm weather in late April brought river temperatures above 60°F by April 27th but then the river temperature rose very slowly, not reaching 70° until May 24th. During the last week of May many of the American shad caught at the West Lift were spent, partially spent or in poor physical condition.

TABLES AND FIGURES

Table 1**Summary of egg production data for spawning tests conducted with hickory shad at Conowingo Dam, Spring, 2009.**

Test #	Start/Stop Date	M/F	Liters of eggs	No. Liters Shipped	Date Shipped
1	4-13/4-20	117/28	1.0	1.0	4/16
			4.7	4.7	4/18
			3.2	3.2	4/19
			2.1	2.1	4/20
2	4-14/4-20	62/27	3.0	3.0	4/16
			7.4	7.4	4/18
			0.5	0.5	4/19
3	4-20/4-28	70/16	3.4	3.4	4/23
			0.5	0.5	4/25
4	4-22/4-28	53/26	3.2	3.2	4/24
			1.4	1.4	4/25
Totals		302/97	30.3	30.3	

Shipment Date	Liters	Total Eggs	No. Viable Eggs	Percent Viable
16-Apr	4	2,224,308	1,918,466	86
18-Apr	12.05	4,261,351	3,780,668	89
19-Apr	3.7	1,296,494	1,161,884	90
20-Apr	2.05	683,979	455,613	67
23-Apr	3.4	1,373,657	1,091,222	79
24-Apr	3.15	941,733	720,705	77
25-Apr	1.9	698,651	613,916	88
Totals	30.25	11,480,173	9,742,474	85

Total Males	302
Total Females	97
Total Fish	399
Total liters of eggs	30.25
Mean liters/test.	7.6
Mean No. of Eggs/ Liter	379,510
Mean No. of Eggs/Female	118,352
Mean No. of Viable Eggs/ Female	100,438

Table 2**Summary of hormone induced spawning trials with hickory shad at Conowingo Dam, 2003-09.**

<i>Year</i>	2003	2004	2005	2006	2007	2008	2009
Start/Finish date	4-15/4-27	4-19/4-26	4-15/4-27	4-11/4-19	4-23/5-1	4-11/4-24	4-13/4-28
Tank diameter (ft)	10, 12	10, 12	10, 12	10, 12	12	10,12	10,12
Tank volume (liters)	6,400 - 9,200	6,400 - 9,200	6,400 - 9,200	6,400 - 9,200	9,200	6,400 - 9,200	6,400 - 9,200
No. of test groups	5	4	8	4	3	4	4
Total fish	381	349	721	398	384	256	399
Males/Females per trial	40/36	48/39	55/34	62/38	59/69	38/26	76/24
Stocking density (fish/liters)	1/99	1/89	1/78	1/71	1/72	1/75-1/221	1/63-1/107
Male:Female ratio	1:0.9	1:0.8	1:0.6	1:0.6	1:1.2	1:0.7	1:0.3
Hormone injected	LHRH _a	LHRH _a	LHRH _a	LHRH _a	LHRH _a	sGnRH _a *	None
Liquid, Pellet	L+P	L+P	L+P	L+P	P	P	N/A
Dose(ug) Male/Female	50/50	50/50	50/50	50/50	25/25	75/75	0
Eggs collected (liters)	30.2	33.4	73.8	26.8	27.9	31.1	30.25
Liters of eggs /Female	0.167	0.215	0.271	0.177	0.135	0.296	0.312
No. eggs/liter	477,607	405,853	388,208	565,893	459,455	315,233	379,510
Total no. of eggs shipped	14,423,730	13,555,505	28,727,411	15,165,928	11,532,320	9,803,731	11,480,173
Viability (%)	44.1	46.1	61.4	60.6	69.3	73.6	84.9
Total number of viable eggs	6,360,865	6,245,259	17,645,251	9,194,583	7,994,797	7,216,392	9,742,474
Total liters of viable eggs	13.3	15.4	45.5	16.3	17.4	22.9	25.7
Adult mortality rate (%)	14.0	3.7	2.2	22.1	3.1	2.3	4.5

*Only two of the four test groups received hormone injections

Table 3

Summary of egg production data for hormone(sGnRH α) induced spawning tests conducted with American shad at Conowingo Dam and shipped to the Van Dyke shad hatchery, Spring, 2009.

Test Group	Treatment/Control	Start/Stop Date	M/F	Liters Collected	River Release	Total Liters Shipped	Date Shipped
1	Treatment	4-30/5-4	30/23	7.5		7.5	2-May
				3.0		3	3-May
2	Treatment	5-1/5-4	45/30	6.6	0.6	6	3-May
3	Treatment	5-4/5-7	30/20	7.7	0.6	7.1	6-May
4	Treatment	5-4/5-7	45/30	7.1		7.1	6-May
5	Treatment	5-7/5-10	30/20	6.5		6.5	9-May
6	Control	5-7/5-13	45/30	2.0	0.5	1.5	13-May
7	Treatment	5-11/5-13	30/20	7.0		7.0	13-May
8	Treatment	5-13/5-15	30/20	6.1		6.1	15-May
9	Treatment	5-13-5-15	45/30	7.0		7.0	15-May
10	Treatment	5-15/5-18	45/30	8		8	17-May
11	Control	5-15/5-22	30/20	0		0	
12	Treatment	5-18/5-20	45/30	11		11	20-May
13	Treatment	5-20/5-22	45/30	11.3		11.3	22-May
14	Treatment	2-22/5-24	21/20	7.6		7.6	24-May
15	Control	5-22/5-28	45/30	0		0	
16	Control	5-24/5-29	30/20	0.3	0.3	0	
Totals			591/403	98.7	2.0	96.7	

Shipping Date	Liters Shipped	No. eggs	No. Viable	Viabil.(%)
2-May	7.5	476,350	233,630	49
3-May	9.0	513,428	37,898	7
6-May	14.2	847,498	86,166	10
9-May	6.5	412,837	109,698	27
13-May	8.5	478,477	25,583	5
15-May	13.1	800,367	277,736	35
17-May	8.0	486,396	20,006	4
20-May	11.0	710,832	196,345	28
22-May	11.3	705,327	300,393	43
24-May	7.6	453,993	79,022	17
Totals	96.7	5,885,504	1,366,478	23

	Treatment	Control
Total Males	441	150
Total Females	303	100
Total Fish	744	250
Mean vol.(liters) / test group	8.0	0.6
Mean No. of Eggs / Liter	60,864	N/A
Mean No. of Eggs/Female	19,123	N/A
Mean No. of Viable Eggs/ Female	4,436	N/A

Table 4**Summary of hormone induced spawning trials with American shad at Conowingo Dam, 2001-2009.**

<i>Year:</i>	2001	2002	2003	2004	2005	2006	2007	2008	2009
Start/Finish date	4-30/6-4	4-24/6-6	4-28/6-5	4-27/5-27	4-27/6-6	4-20/6-3	5-4/5-30	4-25/6-6	4-30/5-29
Tank diameter (ft)	12	10,12	10,12	10,12	10,12	10,12	10,12	10,12	10,12
Tank volume (liters)	9,200	15,600	15,600	15,600	15,600	15,600	15,600	15,600	15,600
Number of test groups	10	10	12	10	11	20	14	16	16
Total fish	599	1,000	1,504	1,055	1,135	1,557	1,504	1010	994
Males/Females per trial	36/24	66/34	75/50	75/50	75/50	47/31	75/50	38/25	37/25
Stocking density (fish/liters)	1/153	1/156	1/125	1/125	1/125	1/124	1/125	1/125	1/125
Male:Female ratio	3:2	2:1	3:2	3:2	3:2	3:2	3:2	3:2	3:2
Hormone injected	LHRHa	sGnRHa	LHRHa	LHRHa	LHRHa	LHRHa	LHRHa	sGnRHa*	sGnRHa*
Liquid, Pellet	P	P	L+P	L+P	L+P	L+P	L+P	P	P
Dose (ug) Male/Female	75/150	150/150	150/150	150/150	150/150	150/150	25-45/75-95	75/75	75/75
Eggs collected (liters)	103	146.8	234	90.4	160.5	169.25	89.6	110.5	98.7
Liters of eggs /Female	0.429	0.432	0.387	0.244	0.418	0.270	0.148	0.272	0.318
No. eggs/liter	63,140	51,235	51,187	59,775	53,828	60,747	80,638	58,429	60,864
Total number of eggs shipped	6,503,420	7,521,346	11,970,764	5,403,660	7,998,778	10,281,444	6,773,594	5,749,467	5,885,504
Viability (%)	33.2	10.1	17.7	20	23.9	21.7	8.9	9.8	23.2
Total number of viable eggs	2,159,135	760,935	2,118,852	1,080,732	1,913,801	2,232,459	603,345	526,816	1,366,478
Total liters of viable eggs	34.20	14.85	41.42	18.1	35.6	36.75	7.97	9.64	22.45
Adult mortality rate (%)	6.0	3.6	2.0	11.5	3.3	3.5	8.3	10.3	15.0

*Only 12 of the 16 test groups received hormone injections

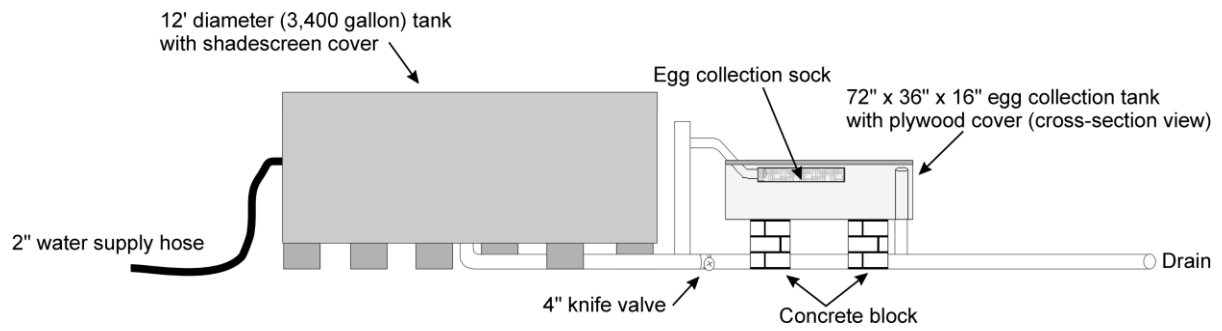


Figure 1

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

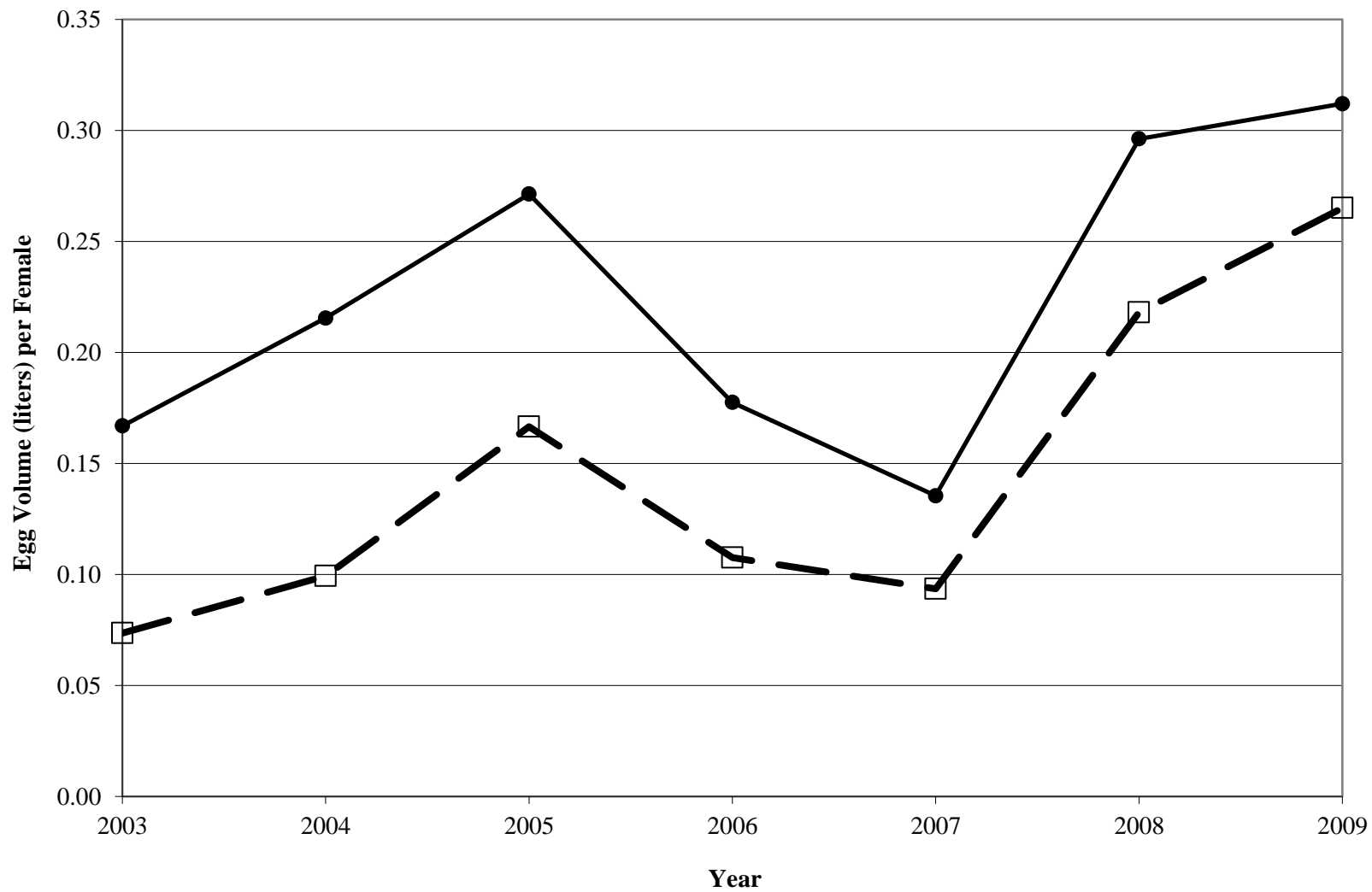


Figure 2 Comparison of total hickory shad egg volume (solid line) and viable egg volume (broken line) per female for the spawning tests conducted at Conowingo Dam, 2003-2009.

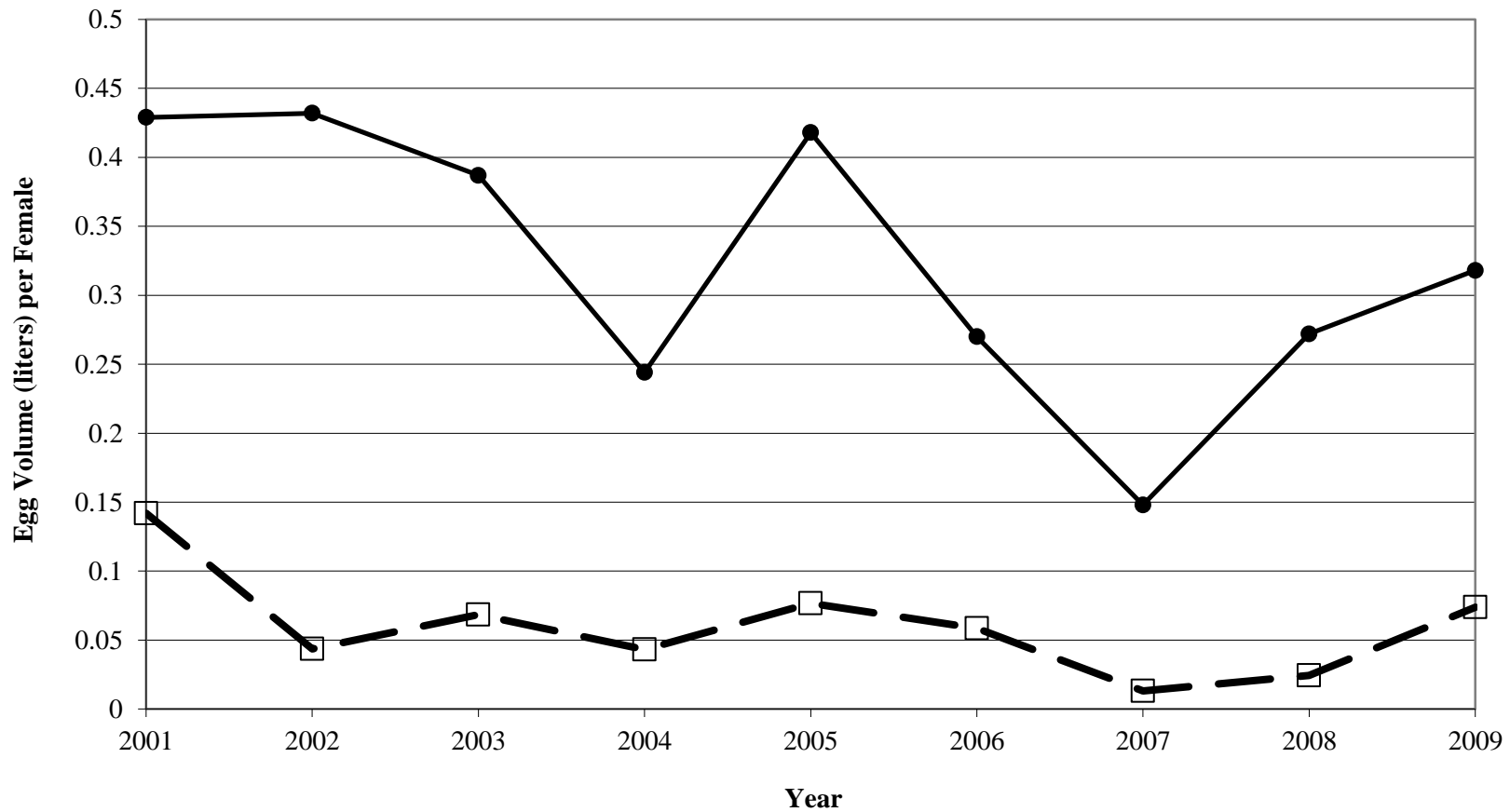


Figure 3. Comparison of total American shad egg volume (solid line) and viable egg volume (broken line) per female for the spawning tests conducted at Conowingo Dam, 2001-2009.

APPENDIX A

Appendix Table A-1.

Individual test group data for hickory shad spawning tests conducted at Conowingo Dam West Fish Lift, Spring 2009.

Test Group 1							
M/F Ratio	117/28	12 ft tank					
Start Date	4/13/09	1500					
End Date	4/20/09	0735					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
4/13/09	1515	11.2	10.0				
4/14/09	1510	10.7	10.7				
4/15/09	0740	10.5	9.8				
4/16/09	0730	10.0	8.9				
4/16/09	1120	11.2	10.6	1.0	1.0		
4/17/09	0730	10.9	10.1				
4/17/09	1210	11.8	10.2				
4/18/09	1030	12.0	10.4	4.7	4.7		
4/19/09	1035	12.5	10.2	3.2	3.2		
4/20/09	0730	12.7	10.4	2.05	2.05		1m,2f

Test Group 2							
M/F Ratio	62/27	10 ft tank					
Start Date	4/14/09	1500					
End Date	4/20/09	1420					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
4/14/09	1510	10.5	10.6				
4/15/09	0742	10.5	8.8				
4/16/09	0730	10.0	10.5				
4/16/09	1100	11.0	10.6	3.0	3.0		
4/17/09	0732	10.9	9.3				
4/17/09	1212	11.8	10.6				
4/18/09	1035	12.0	10.6	7.35	7.4		
4/19/09	1030	12.5	10.6	0.5	0.5		
4/20/09	0730	12.7	10.8				3m

Appendix Table A-1.**Continued.**

Test Group 3							
M/F Ratio	70/16	12 ft tank					
Start Date	4/20/09	1400					
End Date	4/28/09	0800					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
4/20/09	1400	12.8	10.2				
4/21/09	0740	13.0	10.1				
4/22/09	0715	13.8	10.0				
4/22/09	1525	14.9	10.3				
4/23/09	0718	14.0	10.0	3.4	3.4		
4/24/09	0721	13.8	10.2				
4/24/09	1155	14.4	10.5				
4/25/09	0958	14.4	10.1	0.5	0.5		
4/26/09	0901	15.0	10.2	0.1		0.1	1m
4/27/09	0727	15.3	9.7	<0.1		<0.1	1m
4/28/09	0718	16.0	9.8				1m, 1f

Test Group 4							
M/F Ratio	53/26	10 ft tank					
Start Date	4/22/09	1500					
End Date	4/28/09	0745					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
4/22/09	1520	14.9	9.9				
4/23/09	0720	14.0	9.9				
4/23/09	1130	14.5	9.8				
4/24/09	0723	13.8	10.0				
4/24/09	1140	14.4	10.3	3.15	3.15		
4/25/09	0955	14.4	9.8	1.4	1.4		
4/26/09	0903	15.0	10.0	0.6		0.6	2m
4/27/09	0725	15.3	9.5	<0.1		<0.1	2m
4/28/09	0716	16.0	9.6				2m, 2f

Appendix Table A-2.**Individual test group data for hormone induced American shad spawning tests conducted at Conowingo Dam West Fish Lift, Spring 2009.**

Test Group 1							
M/F	30/23	10 ft tank					
Start Date	4/30/09	1030		Dose/fish 0 ug sGnRH α (pellet implant)			
End Date	5/4/09	0900					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
4/30/09	1730	17.8	6.9				
5/1/09	1728	18.9	6.0				
5/2/09	0930	18.9	8.0	7.5	7.5		
5/3/09	0834	19.6	6.4	3.0	3.0		3f
5/4/09	0830	19.4	6.4				4f, 1m

Test Group 2							
M/F	45/30	12 ft tank					
Start Date	5/1/09	1400		Dose/fish 75 ug sGnRH α (pellet implant)			
End Date	5/4/09	0930					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/1/09	1730	18.9	6.2				
5/2/09	0932	18.9	7.5				
5/3/09	0835	19.5	6.6	6.5	6.5		
5/4/09	0830	19.4	6.8	0.6		0.6	2f, 2m

Test Group 3							
M/F	30/20	10 ft tank					
Start Date	5/4/09	1025		Dose/fish 75 ug sGnRH α (pellet implant)			
End Date	5/7/09	1000					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/5/09	0956	19.5	7.8				
5/6/09	0817	18.1	7.8	7.1	7.1		
5/7/09	0815	17.8	7.4	0.6		0.6	1m, 3f

Appendix Table A-2.**Continued.**

Test Group 4							
M/F	45/30	12ft tank					
Start Date	5/4/09	1100		Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/7/09	1015					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/5/09	0957	19.5	7.1				
5/6/09	0815	18.1	8.0	7.1	7.1		1f
5/7/09	0815	17.8	7.2				1f
Test Group 5							
M/F	30/20	10 ft tank					
Start Date	5/7/09	1045		Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/10/09	1545					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/7/09	1548	18.3	8.0				
5/8/09	0856	17.3	7.7				
5/9/09	1045	18	7.9	6.5	6.5		
5/10/09	0900	18.5	8.2	<0.1		<0.1	5f
Test Group 6 (control)							
M/F	45/30	12 ft tank					
Start Date	5/7/09	1115		Dose/fish 0 ug sGnRH _a			
End Date	5/13/09	0900					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/7/09	1550	18.4	8.0				
5/8/09	0858	17.3	7.8				
5/9/09	1047	18.0	8.0				
5/10/09	0902	18.5	8.0				
5/11/09	0920	18.0	7.6	0.5		0.5	3f
5/12/09	0915	17.8	8.3	1.5	1.5		1m, 3f

Appendix Table A-2.

Continued.

Test Group 7							
M/F	30/20	10 ft tank					
Start Date	5/11/09			Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/13/09						
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/11/09	1315	18.0	7.4				
5/12/09	0915	18.0	8.5				
5/12/09	1700	19.0	7.0				
5/13/09	0830	18.2	7.7	7.0	7.0		

Test Group 8							
M/F	30/20	10 ft tank					
Start Date	5/13/09	1000		Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/15/09	930					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/13/09	1525	18.8	7.6				
5/14/09	0915	18.1	7.8				
5/15/09	0900	18.8	8.0	6.1	6.1		3f

Test Group 9							
M/F	45/30	12 ft tank					
Start Date	5/13/09	1100		Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/15/09	1000					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/13/09	1527	18.8	6.6				
5/14/09	0915	18.1	7.2				
5/15/09	0900	18.8	7.0	7.0	7.0		3f

Test Group 10							
M/F	45/30	12 ft tank					
Start Date	5/15/09	1100		Dose/fish 75 ug sGnRH _a (pellet implant)			
End Date	5/18/09	0930					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/15/09	1624	19.2	7.6				
5/16/09	1118	18.9	6.9				
5/17/09	0915	19.2	7.2	8.0	8.0		
5/18/09	0920	19.2	6.6				1m, 3f

Appendix Table A-2.**Continued.**

Test Group 11 (Control)							
M/F	30/20	10 ft tank					
Start Date	5/15/09	1115		Dose/fish 0 ug sGnRHa			
End Date	5/22/09	1000					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/15/09	1622	19.2	7.7				
5/16/09	1120	18.9	7.5				
5/17/09	0917	19.2	7.4				
5/18/09	0922	19.2	6.9				
5/19/09	0925	18.8	7.8				
5/20/09	0837	19.2	8.6				
5/21/09	0855	19.2	7.7				4m, 15f
5/22/09	0920	19.5	8.4				1m, 3f
Test Group 12							
M/F	45/30	12 ft tank					
Start Date	5/18/09	1100		Dose/fish 75 ug sGnRHa (pellet implant)			
End Date	5/20/09	1000					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/18/09	1701	19.4	6.8				
5/19/09	0927	18.8	6.4				
5/20/09	0835	19.2	7.0				
5/20/09	1000			11.0	11.0		3f
Test Group 13							
M/F	45/30	12 ft tank					
Start Date	5/20/09	1145		Dose/fish 75 ug sGnRHa (pellet implant)			
End Date	5/22/09						
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/20/09	1720	20.1	6.8				
5/21/09	0855	19.2	7.0				
5/21/09	1725	20.2	7.2				
5/22/09	0920	19.5	6.7				
5/22/2009	1000			11.3	11.3		1m, 1f

Appendix Table A-2.

Continued.

Test Group 14							
M/F	21/20	10 ft tank					
Start Date	5/22/09	1130	Dose/fish 75 ug sGnRHa (pellet implant)				
End Date	5/24/09	1030					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/22/09	1500	21.0	9.0				
5/23/09	1025	20.6	7.0				
5/24/09	0915	20.8	7.6	7.6	7.6		2f

Test Group 15 (control)							
M/F	45/30	12 ft tank					
Start Date	5/22/09		Dose/fish 0 ug sGnRHa				
End Date	5/28/09	1300					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/22/09	1500	21.0	8.4				
5/23/09	1027	20.6	6.8				
5/24/09	0917	20.8	6.6				
5/24/19	1520	21.4	7.4				
5/25/09	0837	20.2	7.1				3m, 3f
5/26/09	0915	21.5	6.8				5m, 5f
5/27/09	0920	22.3	7.1				7m, 5f
5/27/09	1522	23.0	6.5				2m, 3f
5/28/09	0842	22.1	7.0				9m, 6f

Test Group 16 (control)							
M/F	30/20	10 ft tank					
Start Date	5/24/09	1145	Dose/fish 0 ug sGnRHa				
End Date	5/29/09	1300					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/24/09	1518	21.4	7.4				
5/25/09	0835	20.1	7.6				
5/26/09	0915	21.3	6.9	0.3		0.3	
5/27/09	922	22.5	6.9				1m, 5f
5/28/09	0844	22.1	6.8				7m, 11f
5/29/09	0841	22.4	6.8				5m, 3f

**MISCELLANEOUS
TABLES AND FIGURES**