REPORT ON HORMONE-INDUCED SPAWNING TESTS WITH AMERICAN AND HICKORY SHAD AT CONOWINGO DAM, SPRING 2008

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 to10,000 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 have been conducted annually since then. 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 2008 were generally similar to those used in the past seven years with the following exceptions: The 2008 study plan for both hickory and American shad spawning tests 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 hickory shad study plan was assigned Study Number 11-375-08-3 and the approved American shad study plan was assigned Study Number 11-375-08-4. The study protocols for the use of Salmon Gonadotropin-Releasing Hormone Analog (sGnRHa) 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 sGnRHa available from Syndel was 75ug per pellet and all treatment fish (hickory and American shad) received this dose in the 2008 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.

As in past years, cooperating anglers at the mouth of Deer Creek were the primary source of hickory shad for the 2008 tests. Deer Creek anglers supplied the pre spawn hickory shad for three (4/11, 4/17, and 4/18) of the four hickory shad spawning tests at the Conowingo Dam West Fish Lift . Maryland DNR personnel provided the hickory shed for the fourth spawning test (4/21) with their electrofishing operations in the lower Susquehanna River near the Lapidum Boat

Launch. Hickory shad appeared in the angler catch at the mouth of Deer Creek during the first week of April as river temperature approached 50°F. The hickory shad were transported 5.6 mi (Deer Creek) or 7.1 mi (Lapidum) to Conowingo Dam by Pennsylvania Fish and Boat Commission (PFBC) personnel in an oxygenated circular tank mounted on a pick-up truck. The transport tank capacity was 30-40 fish per trip. A total of 256 hickory shad was transported between 4/11 and 4/21. Each test was started on the same day that the fish were caught. Prior to injection or placement into the spawning tanks, fish length (total and fork) was recorded and a sub-sample of 30 fish weights was recorded from each test group. Test group size varied from 29 to 85 and was dependent on availability of fish from anglers or electrofishing. A 3:2 (M/F) sex ratio was the goal for hickory shad tests and that ratio was attained in three of the four test groups. 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.

All fish in test groups 2 and 4 (treatments) received a 75ug dose of pelleted sGnRHa (source: Syndel International Inc.), implanted with a RALGUN pellet injector into the musculature of the shoulder region. Test groups 1 and 3 (controls) received no hormone implants. Individual tests lasted 3 to 6 days and were terminated when egg production declined or ceased. Fish were not anesthetized prior to injection. 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. All treatment fish that survived to the end of the test were euthanized and disposed of properly. Control fish that survived the spawning tests 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 1,010 pre-spawned American shad utilized for the 16 spawning tests conducted at Conowingo Dam in 2008.The equipment, hormone treatment (75ug per fish), egg collection/shipping methods and record keeping 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 4/25 and ended on 6/6. 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 31.1 liters of eggs was collected from the four test groups of hickory shad and shipped to the Van Dyke Hatchery in 2008 (Table 1 and Appendix Table A-1). The overall viability of the hickory shad eggs sent to the Van Dyke Hatchery was 73.6% (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 (0.3 liters) was also the highest observed since 2003 (Figure 2). The average viability of eggs produced by the test groups that received the hormone treatment (83.7%) was higher than the viability of eggs produced by the control groups (60.6%). Water temperature in the spawning tanks ranged from 12.0 to 17.5°C and dissolved oxygen levels ranged from 10.1 to 11.8 ppm. Adult mortality rate for hickory shad during the 2008 spawning tests was 2.3%. Mortality in past years has ranged from 2.2-22.1% (Table 2).

A total of 16 on-site spawning trials with 1010 American shad from April 25th to June 6th produced 110.5 liters of eggs (Table 3 and Appendix Table A-2). Over 98 liters of eggs were shipped to the Van Dyke Hatchery and the remaining 12.1 liters were released into the river below Conowingo Dam. The overall estimated viability of the eggs shipped to Van Dyke was 9.8 % (Mike Hendricks, personal communication). The total volume of eggs produced per female in 2008 (0.272 liters) was slightly below the average of 0.333 liter observed for the previous seven years (Figure 3). When adjusted for viability, the volume of viable eggs produced per female in

the 2008 tests averaged 0.024 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 8.3 liters of eggs while control test groups averaged 2.7 liters. 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 14.6 to 19.2°C and 6.0 to 9.5 ppm. Mortality rate for adult American shad during the 2008 tests was 10.3%. Control groups experienced the highest mortalities probably due to the prolonged holding times (up to 7 days). Mortality rates have ranged from 2 to 11.5% in previous years (Table 4).

SUMMARY

The results of the hickory shad hormone-induced spawning tests at Conowingo Dam in 2008 showed a continuation of the high quality levels achieved from 2005 through 2007. The estimated overall egg viability of 73.6% is the highest viability that has been observed in the last six years of hickory shad spawning tests. The two groups of control fish produced almost as many liters of eggs as the two groups of treatment fish indicating that many of this years test fish were close to being fully ripe when they were captured.

This was the eighth year of hormone induced American shad spawning tests at the Conowingo West Fish Lift. The results of the 2008 spawning trials were disappointing in both volume of eggs produced and the lower than average viability. The cause for this year's poor egg quality and quantity for the American shad spawning trials is still unclear. Fluctuating river temperature may have been a factor. Warm weather in late April brought river temperatures above 60°F by April 19th but during the first three weeks of May, river temperature dipped below 60°F three

times. River temperature remained above 60°F after May 24 and rapidly climbed to 70°F by May 30th. 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 hormone (sGnRHa) induced spawning tests conducted with hickory shad at Conowingo Dam, Spring, 2008.

Test #	Treatment/ Control	Start/Stop Date	M/F	Liters of eggs	No. Liters Shipped	Date Shipped	Eggs	No. Viable Eggs	Percent Viable
1	Control	4-11/4-17	45/31	6.3	6.3	4/14	1,831,311	1,516,517	82.8
				4.4	4.4	4/17	1,267,020	0	0.0
2	Treatment	4-17/4-21	51/34	4.3	4.3	4/18	1,172,603	945,628	80.6
				7.1	7.1	4/19	2,289,404	2,058,336	89.9
				0.8	0.8	4/20	325,945	296,859	91.1
3	Control	4-18/4-22	15/14	2.5	2.5	4/20	959,828	880,921	91.8
				0.7	0.7	4/23	225,263	200,000	88.8
4	Treatment	4-21/4-24	40/26	5.1	5.1	4/23	1,732,357	1,318,132	76.1
Totals			**151/105**	**31.1**	**31.1**		**9,803,731**	**7,216,392**	**73.6%**

	Treatment	Control
Total Males	**91**	**60**
Total Females	**60**	**45**
Total Fish	**151**	**105**
Total liters of eggs	**17.2**	**13.9**
Mean liters/test.	**8.6**	**6.95**
Mean No. of Eggs/ Liter	**320,948**	**308,160**
Mean No. of Eggs/Female	**92,005**	**95,187**
Mean No. of Viable Eggs/ Female	**76,983**	**57,721**

Table 2

Summary of hormone induced spawning trials with hickory shad at Conowingo Dam, 2003-08.

Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
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
Tank diameter (ft)	10, 12	10, 12	10, 12	10, 12	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
No. of test groups	5	4	8	4	3	4
Total fish	381	349	721	398	384	256
Males/Females per trial	40/36	48/39	55/34	62/38	59/69	38/26
Stocking density (fish/liters)	1/99	1/89	1/78	1/71	1/72	1/75-1/221
Male:Female ratio	1:0.9	1:0.8	1:0.6	1:0.6	1:1.2	1:0.7
Hormone injected	$LHRH_a$	$LHRH_a$	$LHRH_a$	$LHRH_a$	$LHRH_a$	sGnRHa*
Liquid, Pellet	L+P	L+P	L+P	L+P	P	P
Dose(ug) Male/Female	50/50	50/50	50/50	50/50	25/25	75/75
Eggs collected (liters)	30.2	33.4	73.8	26.8	27.9	31.1
Liters of eggs /Female	0.167	0.215	0.271	0.177	0.135	0.296
No. eggs/liter	477,607	405,853	388,208	565,893	459,455	315,233
Total number of eggs shipped	14,423,730	13,555,505	28,727,411	15,165,928	11,532,320	9,803,731
Viability (%)	44.1	46.1	61.4	60.6	69.3	73.6
Total number of viable eggs	6,360,865	6,245,259	17,645,251	9,194,583	7,994,797	7,216,392
Total liters of viable eggs	13.32	15.39	45.45	16.25	17.4	22.9
Adult mortality rate (%)	14.0	3.7	2.2	22.1	3.1	2.3

*Only two of the four test groups received hormone injections

Table 3

Summary of egg production data for hormone(sGnRHa) induced spawning tests conducted with American shad at Conowingo Dam, Spring, 2008.

Test Group	Treatment/ Control	Start/Stop Date	M/F	liters Collected	River Release	Total Liters Shipped	Date Shipped	No. eggs	No. Viable	Viabil.(%)
1	Control	4-25/5-4	30/20	<0.1	<0.1					
2	Treatment	4-27/4-30	45/30	13.6		13.6	4/29	546,891	117,263	20.3%
3	Control	5-4/5-9	30/20	1.7	1.7					
4	Treatment	5-7/5-9	45/30	6.5		6.5	5/9	546,891	20,116	10.9%
5	Treatment	5-9/5-11	30/20	6.5		6.5	5/11	409,267	67,840	16.6%
6	Treatment	5-9/5-11	44/30	5.8		5.8	5/11	378,043	54,800	14.5%
7	Treatment	5-11/5-13	30/20	8.7		8.7	5/13	501,574	80,532	16.1%
8	Treatment	5-11/5-13	45/30	8.6		8.6	5/13	495,592	79,571	16.1%
9	Treatment	5-13/5-16	42/30	6.3	1.5	4.8	5/15	334,875	3,028	0.9%
10	Treatment	5-17/5-19.	30/20	6.1		6.1	5/19	409,470	9,071	2.2%
11	Treatment	5-17/5-19	45/30	6.1		6.1	5/19	409,470	9,071	2.2%
12	Treatment	5-19/5-22	30/20	7.2		7.2	5/21	386,022	12,531	3.2%
13	Treatment	5-19/5-22	45/30	10.4	0.8	9.6	5/21	558,375	44,631	8.0%
14	Treatment	5-26/5-29	38/26	14	0.4	13.6	5/28	689,748	28,363	4.1%
15	Control	5-27/6-6	45/30	7.5	6.2	1.3	6/3	52,687	0	0.0%
16	Control	5-29/6-6	30/20	1.5	1.5					
Totals			**604/406**	**110.5**	**12.1**	**98.4**		**5,749,467**	**526,816**	**9.8%**

	Treatment	Control
Total Males	469	135
Total Females	316	90
Total Fish	785	225
Mean vol.(liters) / test group	8.3	2.7
Mean No. of Eggs / Liter	58,669	40,528
Mean No. of Eggs/Female	18,474	N/A
Mean No. of Viable Eggs/ Female	1,684	N/A

Table 4

Summary of hormone induced spawning trials with American shad at Conowingo Dam, 2001-2008.

Year:	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
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
Tank diameter (ft)	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
Number of test groups	10	10	12	10	11	20	14	16
Total fish	599	1,000	1,504	1,055	1,135	1,557	1,504	1010
Males/Females per trial	36/24	66/34	75/50	75/50	75/50	47/31	75/50	38/25
Stocking density (fish/liters)	1/153	1/156	1/125	1/125	1/125	1/124	1/125	1/125
Male:Female ratio	3:2	2:1	3:2	3:2	3:2	3:2	3:2	3:2
Hormone injected	LHRHa	sGnRHa	LHRHa	LHRHa	LHRHa	LHRHa	LHRHa	sGnRHa*
Liquid, Pellet	P	P	L+P	L+P	L+P	L+P	L+P	P
Dose (ug) Male/Female	75/150	150/150	150/150	150/150	150/150	150/150	25-45/75-95	75/75
Eggs collected (liters)	103	146.8	234	90.4	160.5	169.25	89.6	110.5
Liters of eggs /Female	0.429	0.432	0.387	0.244	0.418	0.270	0.148	0.272
No. eggs/liter	63,140	51,235	51,187	59,775	53,828	60,747	80,638	58,429
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
Viability (%)	33.2	10.1	17.7	20	23.9	21.7	8.9	9.8
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
Total liters of viable eggs	34.20	14.85	41.42	18.1	35.6	36.75	7.97	9.64
Adult mortality rate (%)	6.0	3.6	2.0	11.5	3.3	3.5	8.3	10.3

*Only 12 of the 16 test groups received hormone injections

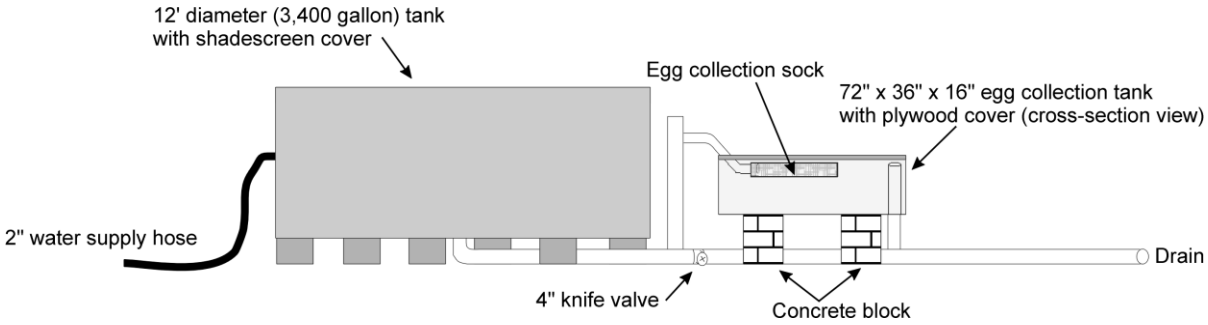

Figure 1

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

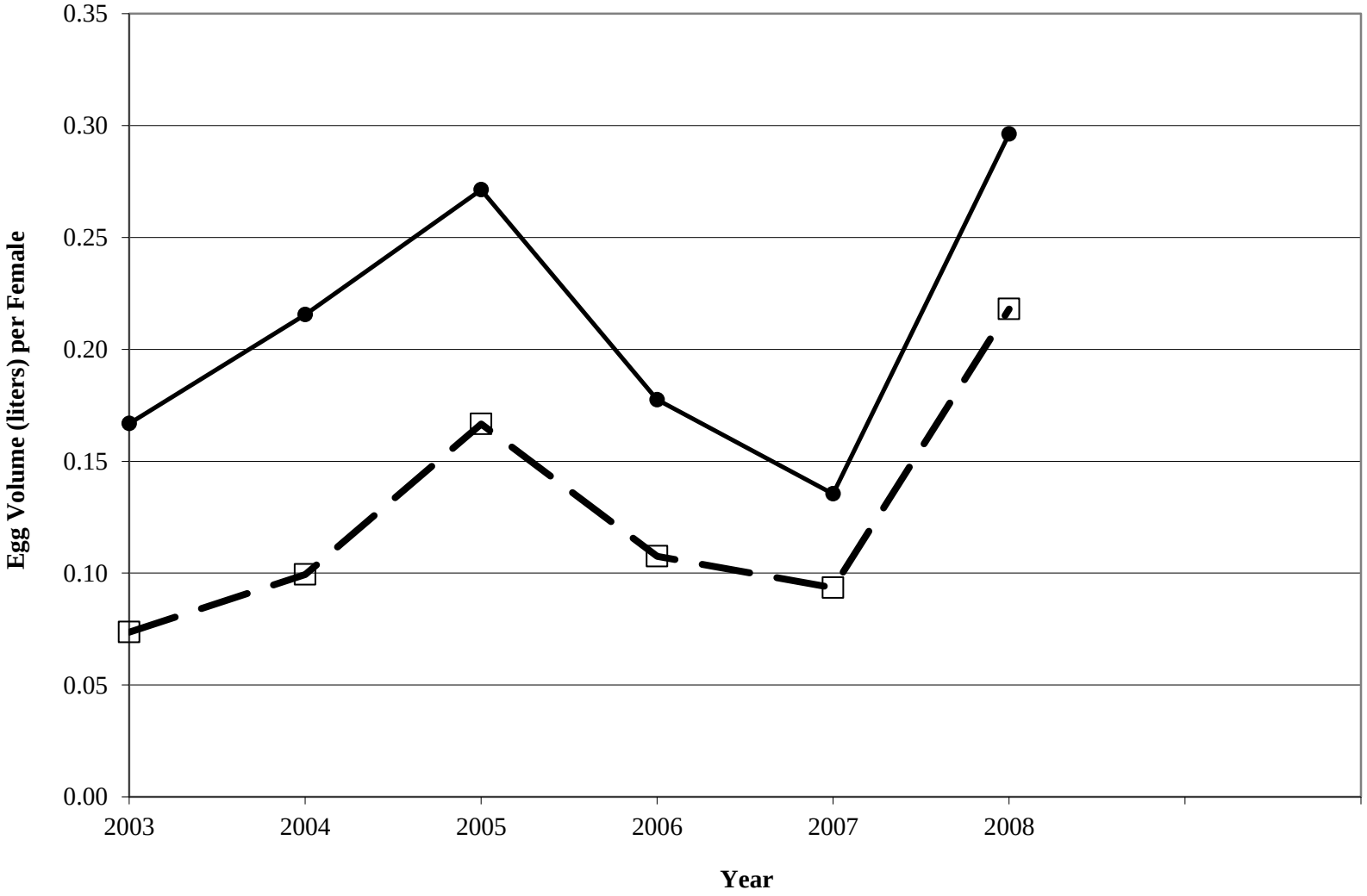

Figure 2 Comparison of total hickory shad egg volume (solid line) and viable egg volume (broken line) per female for the spawning tests conducted at Conowingo Dam, 2003-2008.

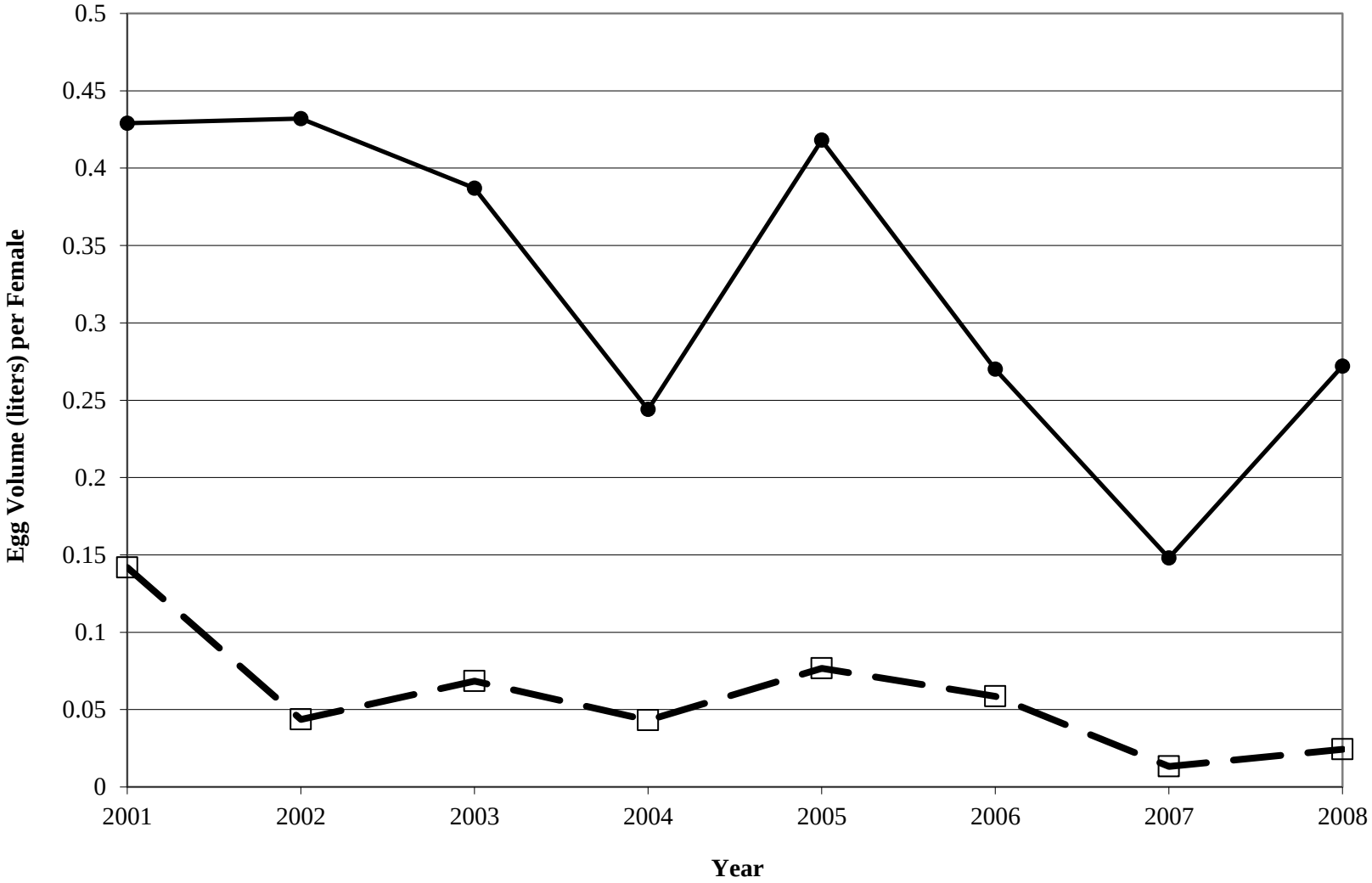

Figure 3 Comparison of total American shad egg volume (solid line) and viable egg volume (broken line) per female for the spawning tests conducted at Conowingo Dam, 2001-2008.

APPENDIX A

Appendix Table A-1

Individual test group data for hormone induced hickory shad spawning tests conducted at Conowingo Dam West Fish Lift, Spring 2008.

Test Group 1 (control)

M/F Ratio	45/31				10 ft tank		
Start Date	4/11/08	1430			Dose/fish 0 ug sGnRHa		
End Date	4/17/08	0900					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
4/11/08	1530	12.0	9.9				
4/12/08	1250	13.0	9.8				
4/13/08	0935	12.9	9.6				
4/14/08	0730	13.7	9.5	6.3	6.3		
4/15/08	0730	13.8	9.5				
4/16/08	0740	13.7	9.9				
4/17/08	0745	13.9	10.6	4.4	4.4		1f

Test Group 2

M/F Ratio	51/34				10 ft tank		
Start Date	4/17/08	1630			Dose/fish 75 ug sGnRHa (pellet)		
End Date	4/21/08	0900					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
4/17/08	1630	14.7	10.0				
4/18/08	0845	14.8	11.2				
4/18/08	1430	15.2	10.8	4.25	4.25		
4/19/08	1000	15.0	11.1	7.05	7.05		
4/20/08	0900	15.2	10.4	0.8	0.8		
4/21/08	0830	16.8	11.0				2m,3f

Test Group 3 (control)

M/F Ratio	15/14				12 ft tank		
Start Date	4/18/08	1430			Dose/fish 0 ug sGnRHa		
End Date	4/22/08						
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
4/18/08	1430	15.2	11.2				
4/19/08	0930	15.0	11.8				
4/20/08	0900	15.2	10.8	2.5	2.5		
4/21/08	0830	16.7	11.3				
4/22/08	0830	16.9	10.5				
4/23/08	0745	17.5	10.1				
4/23/08	0930			0.7	0.7		0

Appendix Table A-1

Continued.

Test Group 4							
M/F Ratio	40/26				10 ft tank		
Start Date	4/21/08	1400			Dose/fish 75 ug sGnRHa (pellet)		
End Date	4/24/08	1000					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
4/21/08	1400	17.2	10.3				
4/22/08	0830	17.0	10.1				
4/23/08	0745	17.5	9.8	5.1	5.1		
4/24/08	1000	18.1	9.6	<0.1		<0.1	0

Appendix Table A-2

Individual test group data for hormone induced American shad spawning tests conducted at Conowingo Dam West Fish Lift, Spring 2008.

Test Group 1 (control)

M/F	30/20	10 ft					
Start Date	4/25/08	1700		Dose/fish 0 ug sGnRHa (pellet implant)			
End Date	5/4/08	0930					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
4/25/08	1815	19.1	9.1				
4/26/08	0840	18.4	8.4				
4/27/08	1350	18.5	6.4				
4/28/08	0855	19.2	7.2				
4/28/08	1650	19.0	6.8				
4/29/08	0945	18.2	6.9	<0.1		<0.1	
4/30/08	0950	17.3	7.4				6f
5/1/08	0905	15.8	8.2				3f,3m
5/2/08	0920	15.1	8.8				1m
5/3/08	0920	15.3	9.5				
5/4/08	0915	15.5	8.6				2m, 2f

Test Group 2

M/F	45/30	12 ft tank					
Start Date	4/27/08	1330		Dose/fish 75 ug sGnRHa (pellet implant)			
End Date	4/30/08	0945					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
4/27/08	1345	18.5	8.4				
4/28/08	0855	19.2	7.1				
4/28/08	1650	19.0	6.0				
4/29/08	0945	18.2	6.2	13.6	13.6		
4/30/08	0945	17.2	7.2	1		1	1f

Test Group 3 (control)

M/F	30/20	10ft tank					
Start Date	5/4/08	1630		Dose/fish 0 ug sGnRHa (no pellet implant)			
End Date	5/9/08	0930					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/4/08	1715	16.9	9.0				
5/5/08	0930	16.3	9.4				
5/6/08	0835	16.7	9.4				
5/7/08	0840	17.1	9.6				1f
5/8/08	0941	18.2	9.2	0.7		0.7	6f
5/9/08	0915	18.2	8.2	< 0.1		< 0.1	2m,6f

Appendix Table A-2

Continued.

Test Group 4

M/F	45/30	12ft tank					
Start Date	5/7/08	945		Dose/fish 75 ug sGnRHa (pellet implant)			
End Date	5/9/08	1100					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/7/08	1600	19.0	9.3				
5/8/08	0943	18.2	8.5				0
5/9/08	0920	18.2	8.2	6.5	6.5		4m,6f

Test Group 5

M/F	30/20	10 ft tank					
Start Date	5/9/08	1100		Dose/fish 75 ug sGnRHa (pellet implant)			
End Date	5/11/08	1030					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/9/08	1720	18.5	7.3				
5/10/08	0935	17.8	7.8				
5/11/08	0915	18.1	7.5	6.5	6.5		1f

Test Group 6

M/F	44/30	12 ft tank					
Start Date	5/9/08	1200		Dose/fish 75 ug sGnRHa (pellet implant))			
End Date	5/11/08	1100					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/9/08	1720	18.5	7.7				
5/10/08	0935	17.8	7.6				
5/11/08	0915	18.1	7.7	5.8	5.8		1m,2f

Test Group 7

M/F	30/20	10 ft tank					
Start Date	5/11/08	1130		Dose/fish 75 ug sGnRHa (pellet implant)			
End Date	5/13/08	1530					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/11/08	1535	18.0	8.0				
5/12/08	0935	17.9	7.7				
5/13/08	0910	16.5	7.6	8.7	8.7		1f

Appendix Table A-2

Continued.

Test Group 8

M/F	45/30	12 ft tank					
Start Date	5/11/08	1330		Dose/fish 75 ug sGnRHa (pellet implant)			
End Date	5/13/08	1130					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/11/08	1535	18.0	7.5				
5/12/08	0935	17.9	7.5				
5/13/08	0910	16.5	7.7				
5/13/08	1100			8.6	8.6		0

Test Group 9

M/F	42/30	12 ft tank					
Start Date	5/13/08	1230		Dose/fish 75 ug sGnRHa (pellet implant)			
End Date	5/16/08	1600					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/13/08	1645	17.6	8.0				
5/14/08	0946	16.7	9.5				
5/15/08	0910	16.2	9.3	4.8	4.8		1m
5/16/08	0900	16.6	8.0	1.5		1.5	0

Test Group 10

M/F	30/20	10 ft tank					
Start Date	5/17/08	945		Dose/fish 75 ug sGnRHa (pellet implant)			
End Date	5/19/08	1000					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/17/08	1155	17.2	8.0				
5/8/08	0900	17.1	8.5				
5/19/08	0900	16.6	8.4	6.1	6.1		1m

Test Group 11

M/F	45/30	12 ft tank					
Start Date	5/17/08	1145		Dose/fish 75 ug sGnRHa (pellet implant)			
End Date	5/19/08	1030					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/17/08	1155	17.2	7.8				
5/18/08	0900	17.1	8.2				
5/19/08	0900	16.6	8.0	6.2	6.2		2m,4f

Appendix Table A-2

Continued.

Test Group 12

M/F	30/20	10 ft tank					
Start Date	5/19/08	1100		Dose/fish 75 ug sGnRHa (pellet implant)			
End Date	5/22/08	1000					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/19/08	1230	16.7	6.8				
5/20/08	1020	15.4	8.2				
5/21/08	0945	15.2	8.9	7.2	7.2		
5/22/08	0845	14.7	9.4	0.7		0.7	1m

Test Group 13

M/F	45/30	12 ft tank					
Start Date	5/19/08	1200		Dose/fish 75 ug sGnRHa (pellet implant)			
End Date	5/22/08	1030					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/19/08	1230	16.7	7.2				
5/20/08	1020	15.4	8.6				
5/21/08	0945	15.2	8.8	9.6	9.6		
5/22/08	0843	14.6	9.2	0.8		0.8	1f

Test Group 14

M/F	38/26	10 ft tank					
Start Date	5/26/08	1045		Dose/fish 75 ug sGnRHa (pellet implant)			
End Date	5/29/08	1200					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/26/08	1415	16.4	8.6				
5/27/08	0907	17.1	8.9				
5/27/08	1645	19.2	9.8				
5/28/08	0915	18.0	8.9				
5/28//08	1100	18.0	8.9	13.6	13.6		
5/29/08	1145	18.6	7.2	0.4		0.4	1m,2f

Appendix Table A-2

Continued.

Test Group 15 (control)

M/F	45/30	12 ft tank					
Start Date	5/27/08	1645					
End Date	6/6/08	0900					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/27/08	1645	19.5	10.2				
5/28/08	0915	18.0	8.9				
5/29/08	1150	18.6	8.1				
5/30/08	0900	19.1	8.1				1m
5/31/08	0830	20.2	7.7	0.9		0.9	
6/1/08	1038	21.5	7.6				2m
6/2/08	0935	21.9	6.5	0.8		0.8	1m, 2f
6/3/08	0730	22.4	6.6				
6/3/08	0815	22.4	6.6	1.3	1.3		1m
6/4/08	0735	22.7	6.4	2.1		2.1	1m
6/5/08	0730	23.2	6.4	2.4		2.4	2f
6/6/08	0740	23.5	6.3	2.0		2.0	6m, 2f

Test Group 16 (control)

M/F	30/20	10 ft tank					
Start Date	5/29/08	1230		Dose/fish 0 ug sGnRHa (pellet implant)			
End Date	6/6/08	0830					
Date	Time	Temp. (°C)	Oxygen (ppm)	Eggs (Liters) Collected	Eggs Shipped	River Releases	Morts Removed
5/29/08	1420	19.9	8.6				
5/30/08	0900	19.1	8.3				
5/31/08	0840	20.2	8				
6/1/08	1043	21.5	7.8				1f
6/2/08	0933	21.9	6.9	trace (<0.1)		<0.1	3m, 4f
6/3/08	0732	22.4	7.3	0.1		0.1	3m, 1f
6/4/08	0738	22.7	7.3	1.2		1.2	1m, 5f
6/5/08	0730	23.2	7.4	0.3		0.3	2m, 3f
6/6/08	0740	23.5	7.5	0.4		0.4	1m, 1f

MISCELLANEOUS
TABLES AND FIGURES