IMPACT OF PLANT OPERATIONS ON MIGRATORY FISH REPRODUCTION

2012 Ichthyoplankton Sampling

CONOWINGO HYDROELECTRIC PROJECT

FERC PROJECT NUMBER 405

RSP 3.21

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EXECUTIVE SUMMARY

Exelon Generation Company, LLC (Exelon) has initiated with the Federal Energy Regulatory Commission (FERC) the process of relicensing the 573-megawatt Conowingo Hydroelectric Project (Conowingo Project). The current license for the Conowingo Project was issued on August 14, 1980 and expires on September 1, 2014. FERC issued the final study plan determination for the Project on February 4, 2010, approving the revised study plan with certain modifications. The final study plan determination required Exelon to conduct a characterization of the reproduction of the target anadromous fishes; American shad (*Alosa sapidissima*), hickory shad (*A. mediocris*), river herrings (blueback herring, *A. aestivalis*, and alewife, *A. psuedoharangus*), striped bass (*Morone saxatilis*), and white perch (*M. americana*), below the Conowingo Project. The results could then be compared with those of prior lower Susquehanna River ichthyoplankton studies performed in the early 1980s.

The study area for 2012 was largely based on the studies conducted in the 1980s, encompassing the area from the Conowingo Dam to the Interstate 95 Bridge on the Susquehanna River in Maryland. Ichthyoplankton samples were collected weekly from 3 April to 29 June 2012 by towing a 0.5 meter plankton net, against the current, in twelve designated locations within the study area. The tidal boundary separated the study area into four non-tidal and eight tidal stations. The depth at two of the stations allowed for a surface and bottom sample to be collected, resulting in 14 samples collected for each sampling effort. Sampling was conducted twice weekly during the typical peak of spawning activity in May and early June.

The lower Susquehanna River continues to provide recruitment for many fish species. Nearly 20 different taxa were collected in the plankton nets during the 2012 sampling. The total sampling effort yielded nearly 81,000 specimens from 275 samples collected.

The results of the ichthyoplankton collections in 2012 were mostly similar to those obtained in the early 1980s. Gizzard shad eggs and larvae, continually increasing in numbers in the lower Susquehanna, proved to be the predominant species. White perch eggs and larvae, abundant historically, have dramatically diminished from the sampling area. Reproduction of river herrings continues to be well documented in the lower Susquehanna River.

American shad eggs and larvae were present in samples from early April to mid- May when mean river temperature ranged from 14-19^{0}C. Samples collected on April 10 and May 10, when average river temperatures were 14 and 18^{o}C, respectively, showed the highest abundance of American shad eggs and

larvae. River herrings and gizzard shad were collected during all sampling weeks, with a peak for both species around 18^{0}C in mid -May. Hickory shad were collected mostly in the first six weeks of sampling when river temperature ranged from 13-18^{0}C. Peak white perch spawning also occurred during mid-May when mean river temperatures ranged from 18-19^{o}C. Numerous non-target species were also collected during the study including darters, sunfishes, carps and minnows, and suckers.

Similar to historic results, far more eggs were collected in 2012 than any other life stage. The thirteen weeks of daytime sampling yielded 63 American shad eggs and two yolk sac larvae. Additional *ad hoc* night sampling was performed on three occasions, when previously radio-tagged American shad were present in historic spawning locations. The night sampling led to the collection of six American shad eggs, all collected on the first night of sampling. The effort was shortened due to lack of active radio tagged shad and severe weather threatening the sample area.

Non-tidal stations generally yielded smaller catches of ichthyoplankton, possibly due to the higher velocity of the water carrying the specimens downstream to the tidal stations where velocity is slower. However, the river herrings were notably present in larger numbers at the non-tidal stations, suggesting they are reproducing near the Conowingo Project. Hickory shad were found in good numbers in both tidal and non-tidal stations, both being downstream of historic spawning tributaries (Deer Creek on the western shore and Octoraro Creek on the eastern shore). White perch were found in both tidal and non-tidal areas with the higher densities occurring downstream of the tidal boundary. All four striped bass eggs collected were also found at tidal stations. American shad were collected in similar densities at both tidal and non-tidal stations.

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LIST OF ABBREVIATIONS

Agencies

FERC	Federal Energy Regulatory Commission
MDNR	Maryland Department of Natural Resources
USGS	United States Geological Survey

Units of Measure

C	Celsius, Centigrade
cfs	cubic feet per second
cm	centimeter
F	Fahrenheit
L	liter
m	meter
mg	milligram

Environmental

DO	dissolved oxygen

Miscellaneous

EFL	Conowingo east fish lift
IP	ichthyoplankton

1.0 INTRODUCTION

Exelon Generation Company, LLC (Exelon) has initiated with the Federal Energy Regulatory Commission (FERC) the process of relicensing the 573-megawatt Conowingo Hydroelectric Project (Conowingo Project). The current license for the Conowingo Project was issued on August 14, 1980 and expires on September 1, 2014. FERC issued the final study plan determination for the Project on February 4, 2010, approving the revised study plan with certain modifications.

The final study plan determination required Exelon to conduct a characterization of the reproduction of the target anadromous fishes; American shad (*Alosa sapidissima*), hickory shad (*A. mediocris*), river herrings (blueback herring, *A. aestivalis*, and alewife, *A. psuedoharangus*), striped bass (*Morone saxatilis*), and white perch (*M. american*a) below the Conowingo Dam. A previous report detailed the spawning habitat requirements for these species; existing relevant survey data for early life stages of anadromous fishes in Conowingo Pond and the lower Susquehanna River (below) Conowingo Dam; and existing data regarding characterization of the hydraulic conditions below Conowingo Dam.

The objective of this study was to characterize fish reproduction occurring in the Susquehanna River below the Conowingo Project via ichthyoplankton (IP) collections. The results of the 2012 study were also compared to the historical lower Susquehanna IP collections that occurred from 1982-1984.

2.0 STUDY AREA

This study focused on a stretch of the Susquehanna River, similar to historic ichthyoplankton collections, between the Conowingo Dam and the mouth of the Chesapeake Bay (Figure 2.0-1). The study area stretched approximately five river miles from the area known as "Lee's Ferry" downstream to the Interstate 95 Bridge. The tidal boundary typically occurs near the mouth of Deer Creek (western shore), a tributary near the midpoint of the study area. Consequently, the four stations upstream of the creek were considered non-tidal, and the eight downstream stations considered tidal water (Figure 2.0-1).

The study area was largely based on the 1982-84 ichthyoplankton sampling (Figure 2.0-2). Six of the eight tidal stations (7004 – 7009) were located in the same areas as the historic studies; historic sampling areas below route 95 were not sampled in 2012. Because shad spawning activity was documented (RMC 1985a) around Spencer Island, two new tidal stations (7010, 7022) were included: one on either side of the island. Historically, non-tidal ichthyoplankton sampling occurred just downstream of the Conowingo tailrace, as well as in the mouths of Octoraro and Deer creeks. For this study, non-tidal sampling was focused on the deeper pools that stretch across the river at "Lee's Ferry" and "The Pool" (Figure 2.0-1). Nighttime *ad hoc* sampling events occurred near active radio tagged American shad in historic spawning areas around the islands near Port Deposit, MD (Figure 2.0-3).

3.0 METHODS

Weekly ichthyoplankton sampling occurred over a 13-week period from early April to late June. However, the sampling frequency was increased to twice weekly during the expected peak of spawning activity (1 May – 7 June). A total of 19 daytime sampling events occurred at regular stations and three *ad hoc* sampling events occurred during the night. Daytime surface sampling occurred at the same five transects (12 stations) each week (Figure 2.0-1). Two mid-river stations on the downstream transects, where station depth was greater, were sampled on the bottom as well as the surface, for a total of 14 samples collected during each daytime sampling event.

A series of parameters were recorded before each sample was taken. Station depth readings were taken with a sonar depth finder. Surface temperature and dissolved oxygen readings were measured with a YSI model 550A handheld device. Subsequent to collection, river flow (cfs) associated with each sample, was provided by the Holtwood Hydroelectric Project.

Samples were collected with a 0.5-m plankton net (0.5-mm mesh) equipped with a General Oceanics model 2030 flowmeter. The net was towed behind the boat, heading upstream, for approximately 5 minute durations. For the surface samples, a small float was fixed to the mouth of the plankton net to ensure the net was filtering water approximately one foot below the surface. Weight was added to the mouth of the net for the bottom samples and the tow rope was lengthened to ensure the net was riding on/near the bottom.

The nighttime *ad hoc* sampling events were conducted near shallow historic spawning areas when radio tagged American shad were present. Once a fish was located via radio telemetry in one of these areas, the boat was anchored and the plankton net fished off the stern in a similar fashion to daytime sampling. Both surface and bottom samples were collected during the nighttime sampling.

After five minutes of sampling time, the net was retrieved and its contents were carefully washed into one-quart plastic sample jars. The contents of the jars were then preserved with 5-10% formalin. Jars were immediately labeled and sealed until arrival at the laboratory for sorting and identification.

The procedures used by the laboratory for this study including: sorting, level of identification of species, sub-sampling, etc. are located in Appendix A.

The volume of the water filtered for each sample was measured using the difference in counts measured by the flow meter. By recording the difference in counts for each sample, a sample volume (m^3) could later be calculated using the following formulas:

A. Distance in meters = $\dfrac{\text{Flow meter rotations x Rotor constant}}{999{,}999}$

B. Volume of water filtered (m^3) = $\dfrac{3.14\ (\text{net diameter in m})^2}{4}$ X Distance in meters

*rotor constant= 26,873

4.0 RESULTS

4.1 Sampling Conditions

Surface temperatures during sampling ranged from 13.6 to 29.6°C (Table 4.1-1). River temperature was generally slightly warmer at the lowermost sampling sites and increased with time. Dissolved oxygen readings were ≥ 6.1 mg/L for all samples taken during the study.

Figure 4.1-1 shows the average river flow and surface temperatures while sampling occurred. River flow varied greatly throughout the sampling period, as streamflow increased during the April and May sampling. One high flow event led to the opening of spill gates during mid- May but did not interfere with the sampling process. Greater mean river flows occurred mainly during weeks of peak spawning when two sampling efforts were conducted rather than one. Flows began to significantly decrease in mid -June leading to difficulty in navigating to the non-tidal stations and to slower plankton tows at these stations.

4.2 Eggs and Larvae Abundance

Over 80,000 specimens (eggs and larvae) were collected from 275 samples taken in 2012 (Table 4.2-1). The most abundant species in the study was gizzard shad, contributing to over 50% of the total catch. The second most abundant fishes, the river herrings (consisting of blueback herring and alewives), formed 38% of the total catch. White perch and hickory shad each accounted for less than 2,000 specimens (each ~2% of total catch) (Table 4.2-1). American shad were collected in small numbers in six of the thirteen weeks sampled. Only four striped bass eggs were collected, all in the tidal area between Port Deposit and Interstate 95 Bridge. Carp, white suckers, and darters were also well distributed in the samples.

Table 4.2-2 shows the total number of specimens collected each week by life stage. More eggs than larvae were collected for most species; however, white suckers and white perch were most abundant as larvae. Of the 65 American shad eggs and larvae collected, 63 were eggs. Gizzard shad and river herrings were also mostly collected as eggs. All collected fishes of the family Percidae, along with Atlantic needlefish, rock bass, and largemouth bass were only collected as larvae. One young-of-the-year and one yearling banded darter were the only two fully developed specimens collected during the sampling period.

Catch densities for all species life stages were calculated as number of specimens/100m^3 (Table 4.2-3). Eggs comprised 83% of the total catch. Yolk sac and post yolk sac larvae accounted for 11% and 6% of the catch, respectively. Gizzard shad represented the highest overall density at 273 specimens per 100 cubic meters of water; river herrings were second. Although gizzard shad were highest in densities in both eggs and yolk sac larvae, river herrings comprised a much greater number of post yolk sac larvae collected.

4.3 *Ad hoc* Night Sampling for American Shad Egg Collection

Night sampling resulted in 9 total samples collected during 3 sampling events. Radio-tagged American shad released between April 12 and May 17 were located in the shallows around Spencer Island, just below the tidal boundary. When radio-tagged fish were present in these areas, samples were taken immediately downstream of the active fish. A total of 6 American shad eggs was collected during the sampling effort; all were collected during the first night (May 11). Other species abundance in the night samples was similar to the daytime efforts with gizzard shad and river herrings dominating the catch (Table 4.3-1). Differences in life stage among samples collected were also notably parallel with daytime sampling; with eggs being predominant for most species.

4.4 Comparison with Historical Data

Summarized data were obtained from three reports (RMC 1985a, b, c) presenting the results of the fisheries studies performed on the lower Susquehanna River in 1982-1984 for comparison with the 2012 study results. Results for the 2012 study were similar in most aspects to the ichthyoplankton studies from the early 1980s. Relative to the historical data, most notable differences were the increased abundance of gizzard shad in 2012 and decreased abundance of white perch in 2012. Gizzard shad made up only 3% of the combined 1982-1984 total catch, compared to 56% of the total catch in 2012 (Table 4.4-1). In contrast, white perch comprised 72% of the historical catch and merely 18% of the catch in 2012. The river herrings were abundant in both studies, showing slightly higher numbers in 2012. Striped bass were absent from historical studies (1983-1984) and yielded only four total samples in 2012. A total of only 25 hickory shad were collected in 1983-1984 compared to over 1700 in 2012. As for other species collected, the results for species abundance were similar among the 4 years sampled.

Comparison of 2012 life stages to the historical data also yielded comparable results. In 2012, eggs made up 83% of samples collected. Eggs comprised 81, 85, and 90% of the samples in 1982, 83, and 84, respectively. Yolk sac larvae accounted for 11% of the 2012 catch and 10, 13, and 8% of the 1982-84 samples. Post larvae and older life stages were similarly much lower among the four years sampled.

Total densities collected in 2012 were compared to historical densities in Table 4.4-2. An increase in river herrings is evident in the 2012 study. The total density of all eggs/larvae collected in 2012 falls in between the values for 1983 and 1984 at 5.10 specimens per cubic meter.

4.5 Tidal Boundary Influence on Catches

The differences in catch densities (number/100 m^3) between tidal and non-tidal stations are shown in Table 4.5-1. White perch and gizzard shad larvae and eggs were more common in tidal areas than in the non tidal areas. River herrings were more common in the non-tidal areas than in the tidal areas. Hickory shad were equally common in both areas.

To further assess potential spawning areas, all non-tidal stations, as well as the two most upstream tidal stations, were broken down into individual station catch densities for the anadromous fishes in Table 4.5-2. American shad were most abundant, as both eggs and yolk-sac larvae, at station 7022 which is located adjacent to Spencer Island. American shad eggs were also noticeably present at station 7011, which is above the tidal boundary in the area known as "The Pool." The highest abundance of river herring eggs also occurred at the two stations located in "The Pool." A large catch of post yolk-sac larval river herrings occurred at station 7012, the most upstream station located in the area known as "Lee's Ferry." As for hickory shad, the highest abundance occurred at station 7010, located adjacent to Spencer Island and downstream of the Deer Creek confluence. The highest densities of white perch, as well as the collection of all four striped bass eggs, occurred below the tidal boundary.

5.0 FINDINGS AND CONCLUSIONS

The primary objective of the study, characterization of spawning of the target species (American shad, river herrings, hickory shad , white perch and striped bass) downstream of Conowingo Dam, was fulfilled by the 2012 ichthyoplankton sampling between late April and early June (13 weeks). In addition, nighttime sampling was conducted near the actively moving radio-tagged American shad that had been released for the 2012 adult American shad telemetry study for the Conowingo East Fish Lift (EFL). Collection of shad eggs at the locations of radio-tagged shad at nighttime (known spawning hours, RMC 1985a) provided a corroboration of spawning areas of American shad in the lower Susquehanna River.

Water temperature ranged from 13.6°C to 29.6°C (56.5°F to 85.3°F), and mean daily river flow ranged from 12,300 to 107,300 cfs. Most (>90%) eggs/larvae were collected at water temperatures ≤ 26.0°C (78.8°F). Most eggs and larvae of the primary target species (American shad, river herrings, hickory shad, white perch, and striped bass) were collected at water temperatures ≤ 20.0°C (≤ 68.0°F).

Eggs of at least eight species including all the target species were collected. However, the primary locations, peak water temperatures and capture times varied somewhat between the target species. American shad eggs were found at both tidal and non-tidal stations in 2012. During the 1983 study, nearly all 138 American shad eggs collected were found in tidal waters (RMC 1985b). In 2012, 35% of the American shad eggs obtained were collected upstream of the reported historic spawning areas near Spencer Island (RMC 1985b) where less than 30% of the total sampling effort occurred. This suggests that some American shad may have spawned in the upper portion of the study area closer to the Conowingo tailrace. The nighttime *ad hoc* sampling in 2012 resulted in six American shad eggs near Spencer Island in the tidal area; however, electrical storm events and absence of active radio-tagged shad in the area after the first night of sampling curtailed further efforts to successfully collect more eggs. American shad eggs were collected at water temperature 13.8°C to 19.3°C (56.8°F to 66.7°F) between 3 April and 17 May. Two peaks in numbers of American shad eggs collected occurred on 10 April and 10 May when river temperature was 14 and 18°C.

Hickory shad eggs were found in reasonable numbers for the first six weeks of sampling (early April-mid May). Most hickory shad eggs were collected at water temperatures between 13.6°C and 19.3°C (56.5°F to 66.7°F), a temperature range similar (15.8°C to 18.5°C or 60.4°F to 66.7°F) to that reported for peak spawning for hickory shad in the Susquehanna (Richardson *et al*. 2007). Hickory shad are documented to spawn in Deer Creek, located near the tidal boundary, as well as Octoraro Creek, which is located in the non-tidal area upstream of Lee's Ferry (Richardson *et al*. 2007). In 2012, hickory shad were collected in both tidal and non-tidal stations below the two reported historic spawning tributaries, with highest densities collected below Deer Creek. (Jarzynski and Sadzinski 2009) reported that the hickory shad spawning population in Deer Creek has become the largest of its kind in Maryland.

Although fewer stations were located in the non-tidal area, greater than 70% of the river herring eggs/larvae in 2012 were collected at non-tidal stations. River herring eggs are pelagic in moving water and demersal in still water (Klauda *et al*. 1991b), which may help explain the larger numbers in the non-tidal areas where water velocity was much greater than in tidal areas. The efficacy of the surface tows would be greater at the non-tidal stations where eggs are more likely to be in the water column and susceptible to surface tows. A relatively large catch of river herring eggs in the non-tidal locations suggests that a fair amount of spawning occurs near the Conowingo tailrace.

Only four striped bass eggs were collected during the 2012 sampling; they were all captured in the tidal area. This finding is similar to that reported from the 1980s ichthyoplankton sampling (RMC 1985 a, b, c).

White perch eggs were mostly collected at water temperature between 16.3°C and 20.3°C (61.3°F to 68.5°F) and in the tidal areas. However, compared to the historical data white perch eggs were less abundant in 2012. This is perhaps related to differences in sampling strategies between the two periods. White perch eggs are generally demersal (Stanley and Danie 1983), but can be pelagic in flowing water (Hardy 1978, Setzler-Hamilton 1983). White perch eggs were much more abundant in bottom samples during the 1980s RMC sampling. The smaller number of bottom samples taken in 2012 may have contributed to the much lower numbers of white perch eggs, however, the magnitude of the change in numbers may also suggest that white perch recruitment may be diminishing in the lower Susquehanna. The comparison of yolk-sac larvae densities between 2012 ($0.09/\ m^3$) and 1983 ($0.70/\ m^3$) further indicates a decrease in recruitment. However when compared to yolk-sac larvae densities from 1982 (0.11/m3) and 1984 ($0.18/\ m^3$), numbers of white perch larvae in 2012 were only slightly lower (RMC 1985 a, b, c).

Among the other species, early life stages of gizzard shad were most abundant. They were common throughout the sampling area. Most gizzard shad eggs and larvae were collected at water temperatures of 14.4°C to 26.3°C (57.9°F to 79.3°F). The abundance of gizzard shad in 2012 ($2.72/m^3$) was much higher than in the 1980s ($0.14/m^3$). Since its inadvertent introduction in Conowingo Pond in 1972, its population has exploded both downstream and upstream of Conowingo Dam. During high flow events, a large number of gizzard shad can be flushed out of Conowingo Pond into downstream areas. Two such high-flow events occurred in September 2011 which may have contributed to increased spawning stock of gizzard shad downstream of Conowingo Dam.

Results of the 2012 sampling were compared with those reported from the historical 1982-1984 ichthyoplankton sampling conducted downstream of Conowingo Dam to identify broad differences, if any, in relative abundance, species composition, and spawning locations. Except for increased abundance of gizzard shad and decreased abundance of white perch in 2012, there was much similarity in abundance of species and locations.

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TABLE 4.1-1: MEAN SURFACE WATER TEMPERATURES (^{o}C) AND DISSOLVED OXYGEN VALUES DURING 2012 DAYTIME ICHTHYOPLANKTON SAMPLING IN LOWER SUQUEHANNA RIVER.

		Temp			DO			River Flow (cfs)
Week	**Date**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**at Holtwood Station**
1	**04/03/12**	13.6	14.1	13.78	9.4	10	9.62	26,700
2	**04/10/12**	13.8	15.2	14.31	9.1	10.1	9.55	19,100
3	**04/18/12**	16.3	17.2	16.69	9.3	10.8	9.84	14,900
4	**04/24/12**	15.9	18	17.04	7.4	7.9	7.65	18,000
5	**05/01/12** **05/03/12**	14.4	15.4	14.83	9.2	10.6	9.78	33,600 30,700
6	**05/07/12** **05/10/12**	17.3	19.3	18.3	7.5	11	8.41	50,200 56,700
7	**05/15/12** **05/17/12**	18.4	20.2	19.2	7.5	10.2	8.14	51,500 107,300
8	**05/22/12** **05/24/12**	20.4	22.6	21.48	8	10.6	9.3	41,700 40,400
9	**05/29/12** **05/31/12**	25.1	26.3	25.63	6.1	8.8	7.54	46,900 46,900
10	**06/05/12** **06/07/12**	20.7	22.5	22.02	7.8	9.5	8.79	50,700 42,000
11	**06/12/12**	22.7	23.6	23.32	7	7.8	7.46	26,600
12	**06/19/12**	24.2	24.8	24.64	7.5	8.2	7.89	20,600
13	**06/29/12**	27	29.6	28.14	6.7	9.4	7.82	12,300

TABLE 4.2-1: TOTAL NUMBER OF ICHTHYOPLANKTON COLLECTED WEEKLY IN LOWER SUSQUEHANNA RIVER, 2012.

	WEEK (Sampling date(s), 2012)													
	1 (4/3)	**2** (4/10)	**3** (4/18)	**4** (4/24)	**5** (5/01) (5/03)	**6** (5/07) (5/10)	**7** (5/15) (5/17)	**8** (5/22) (5/24)	**9** (5/29) (5/31)	**10** (6/5) (6/7)	**11** (6/12)	**12** (6/19)	**13** (6/29)	**All**
AMERICAN SHAD	2	31	2		4	24	2							65
HICKORY SHAD	340	167	119	481	475	107	13							1702
RIVER HERRING	223	397	2430	358	541	14233	5531	2140	4228	304	362	98	9	30854
STRIPED BASS			1					3						4
WHITE PERCH	73	87	254	9	18	555	264	98	84		3			1445
GIZZARD SHAD	1094	1105	328	245	3522	11220	8521	8784	8543	1677	624	11	2	45676
CARP AND MINNOW FAMILY		2	11	7	19	36	28	16	24	15	2			160
GOLDFISH				1										1
COMMON CARP				6	11	69	100	49	85	2	21			343
WHITE SUCKER	2			6	32	95	120	32	3		9			299
SUNFISH FAMILY					5	16			1					22
LEPOMIS SPECIES									14				2	16
LARGEMOUTH BASS										1				1
ROCK BASS									1					1
TESSELATED DARTER	1	2	1	2	1	2	6	7						22
YELLOW PERCH		1												1
BANDED DARTER					10	130	76	10	1	2				229
ATLANTIC NEEDLEFISH											2			2
UNKNOWN				1				1	2					4
TOTAL	**1735**	**1792**	**3146**	**1116**	**4638**	**26487**	**14661**	**11140**	**12986**	**2001**	**1023**	**109**	**13**	**80847**

TABLE 4.2-2: WEEKLY ICHTHYOPLANKTON CATCH IN LOWER SUSQUEHANNA RIVER BY LIFE STAGE, 2012.

	Date of Sampling (2012)																																							All				
	4/3		4/10			4/18			4/24			5/1 5/3			5/7 5/10			5/15 5/17			5/22 5/24					5/29 5/31			6/5 6/7			6/12			6/19			6/29		STAGE				
	STAGE		STAGE			STAGE			STAGE			STAGE			STAGE			STAGE			STAGE					STAGE			STAGE			STAGE			STAGE			STAGE		Eggs	YSL	PYSL	YOY	+
	Eggs	YSL	Eggs	YSL	PYSL	Eggs	YSL	PYSL	Eggs	YSL	PYSL	Eggs	YSL	PYSL	Eggs	YSL	PYSL	Eggs	YSL	PYSL	Eggs	YSL	PYSL	YOY	+	Eggs	YSL	PYSL	Eggs	YSL	PYSL	Eggs	YSL	PYSL	Eggs	YSL	PYSL	YSL	PYSL					
AMERICAN SHAD	2		29	2		2						4			24			2																						63	2			
HICKORY SHAD	336	4	50	117		53	66		22	459		368	107		31	76			13																					860	842			
RIVER HERRING	210	13	365	32		2384	23	23	57	232	67	409	107	25	13623	489	120	5317	184	30	1894	65	179			1515	25	2688	172		132			362			98		9	25946	1170	3733		
STRIPED BASS						1															3																			4				
WHITE PERCH		73		87			254			9			18		240	315		61	203		14	84					84						3							315	1130			
GIZZARD SHAD	1091	3	1100	5		288	40		222	22	1	3457	62	3	9150	2070		7789	730	2	8360	397	27			8116	366	61	1558	114	5	372	228	24	2	8	1	2		41505	4047	124		
CARP AND MINNOW FAMILY				1	1		10	1		7			18	1		32	4		10	18		8	8				6	18		1	14		1	1							94	66		
GOLDFISH										1																															1			
COMMON CARP										5	1		8	3	52	14	3	12	19	69	26	18	5			60	13	11	1		1	18	3							169	80	93		
WHITE SUCKER	2									5	1	3	26	3	40	38	17	22	76	22	10	19	3				3						9							77	176	46		
SUNFISH FAMILY												5			16													1												21		1		
LEPOMIS SPECIES																												14											2			16		
LARGEMOUTH BASS																															1											1		
ROCK BASS																												1														1		
TESSELLATED DARTER		1		1	1		1			2			1			1	1		2	4		7																			16	6		
YELLOW PERCH				1																																					1			
BANDED DARTER														10		121	9		66	10		4	4	1	1			1			2										191	36	1	1
ATLANTIC NEEDLEFISH																																	1	1							1	1		
UNKNOWN									1												1					1														3				
TOTAL	1641	94	1544	246	2	2728	394	24	302	742	70	4246	347	45	23176	3156	154	13203	1303	155	10308	602	226	1	1	9692	497	2795	1731	115	155	390	245	388	2	8	99	2	11	68963	7751	4124	1	1

*__YSL__-Yolk-sac larvae, **PYSL** – Post yolk-sac larvae, **YOY**-young-of-year, (+) - yearling or older

****Herring Family = Blueback herrings and alewives**

TABLE 4.2-3: MEAN ICHTHYOPLANKTON DENSITIES (NO./100M^3) BY LIFESTAGE 2012.

	Life Stage						
	Eggs	**YSL**	**PYSL**	**YOY**	**Yearling +**	**Mean Density**	**Counts**
	Mean Density	**Mean Density**	**Mean Density**	**Mean Density**	**Mean Density**	**Sum**	**Sum**
AMERICAN SHAD	0.69	0.02	0	0	0	0.71	65
HICKORY SHAD	7.45	8.73	0	0	0	16.18	1702
RIVER HERRING	166.34	9.43	25.29	0	0	201.12	30854
STRIPED BASS	0.06	0	0	0	0	0.06	4
WHITE PERCH	2.14	9	0	0	0	11.14	1445
GIZZARD SHAD	244.88	26.73	1.04	0	0	272.65	45676
CARP AND MINNOW FAMILY	0	0.87	0.6	0	0	1.47	160
COMMON CARP	1.26	0.82	0.64	0	0	2.73	343
WHITE SUCKER	0.62	1.26	0.32	0	0	2.2	299
SUNFISH FAMILY	0.2	0	0.01	0	0	0.21	22
LEPOMIS SPECIES	0	0	0.17	0	0	0.17	16
LARGEMOUTH BASS	0	0	0.01	0	0	0.01	1
ROCK BASS	0	0	0.01	0	0	0.01	1
TESSELLATED DARTER	0	0.2	0.06	0	0	0.26	22
YELLOW PERCH	0	0.01	0	0	0	0.01	1
BANDED DARTER	0	0.74	0.33	0.02	0.01	1.1	229
ATLANTIC NEEDLEFISH	0	0.01	0.01	0	0	0.02	2
UNKNOWN	0.03	0	0	0	0	0.04	4

***YSL**-Yolk-sac larvae, **PYSL** – Post yolk-sac larvae, **YOY**-young-of-year

TABLE 4.3-1: ICHTHYOPLANKTON COUNTS BY LIFE STAGE FOR 2012 *AD HOC* NIGHTTIME SAMPLING.

	5/11/2012			5/15/2012			5/24/2012			All			
	STAGE			STAGE			STAGE			STAGE			
	Eggs	YSL	PYSL	Eggs	YSL	PYSL	Eggs	YSL	YOY	Eggs	YSL	PYSL	YOY
AMERICAN SHAD	6									6			
HICKORY SHAD		45			6						51		
RIVER HERRRING	386	251	41	1004	9	5	219	9		1609	269	46	
STRIPED BASS							3			3			
WHITE PERCH	16	195		12	53		3	6		31	254		
GIZZARD SHAD	1614	436		1268	46		589	73		3471	555		
CARP AND MINNOW FAMILY		21			1	1		1			23	1	
COMMON CARP	52	12		6	8	41	4	14		62	34	41	
WHITE SUCKER	2	17	14	8	40					10	57	14	
TESSELLATED DARTER								6			6		
BANDED DARTER		120	2		63				1		183	2	1

*YSL-Yolk-sac larvae, PYSL-Post yolk-sac larvae, YOY-young-of-year

TABLE 4.4-1: TOTAL NUMBER OF ICHTHYOPLANKTON COLLECTED 1982-1984, 2012.

Species	1982	1983	1984	Total (1982 – 1984)	% of Total	2012	% of Total
No. Taxa	18	20	22			18	
No. Samples	405	446	471	1322		275	
American shad	7	138	179	324	<1%	65	<1%
Hickory Shad	-	0	25	25	<1%	1702	2%
River Herring	11,772	26,827	26,677	65,276	24%	30,854	38%
Striped Bass	-	0	0	0	0%	4	<1%
White perch	23,270	112,249	61,589	197,108	72%	1,445	18%
Carp	371	307	118	796	<1%	343	4%
Gizzard shad	3,911	3,464	1,886	9,261	3%	45,676	56%
Other	1,040	1,099	806	2,945	1%	762	3%
TOTAL	**40,371**	**144,084**	**91,255**	**275,710**		**80,847**	

*

***1982-84 data taken from RMC, 1985a-c**

-No hickory shad or striped bass totals available from 1982 (non-target species)

TABLE 4.4-2: TOTAL ICHTHYOPLANKTON DENSITIES (NUMBER/M^3) COLLECTED 1982-1984, 2012.

Species	**1982**	**1983**	**1984**	**2012**
No. Taxa	**18**	**20**	**22**	**18**
No. Samples	**405**	**446**	**471**	**275**
American shad	0.00	0.01	0.01	0.01
River Herring	0.59	1.30	0.90	2.01
White perch	1.14	5.34	2.07	0.11
Carp	0.02	0.01	0.00	0.03
Gizzard shad	0.19	0.17	0.06	2.73
Other	0.04	0.05	0.03	0.22
TOTAL	**1.98**	**6.88**	**3.07**	**5.10**

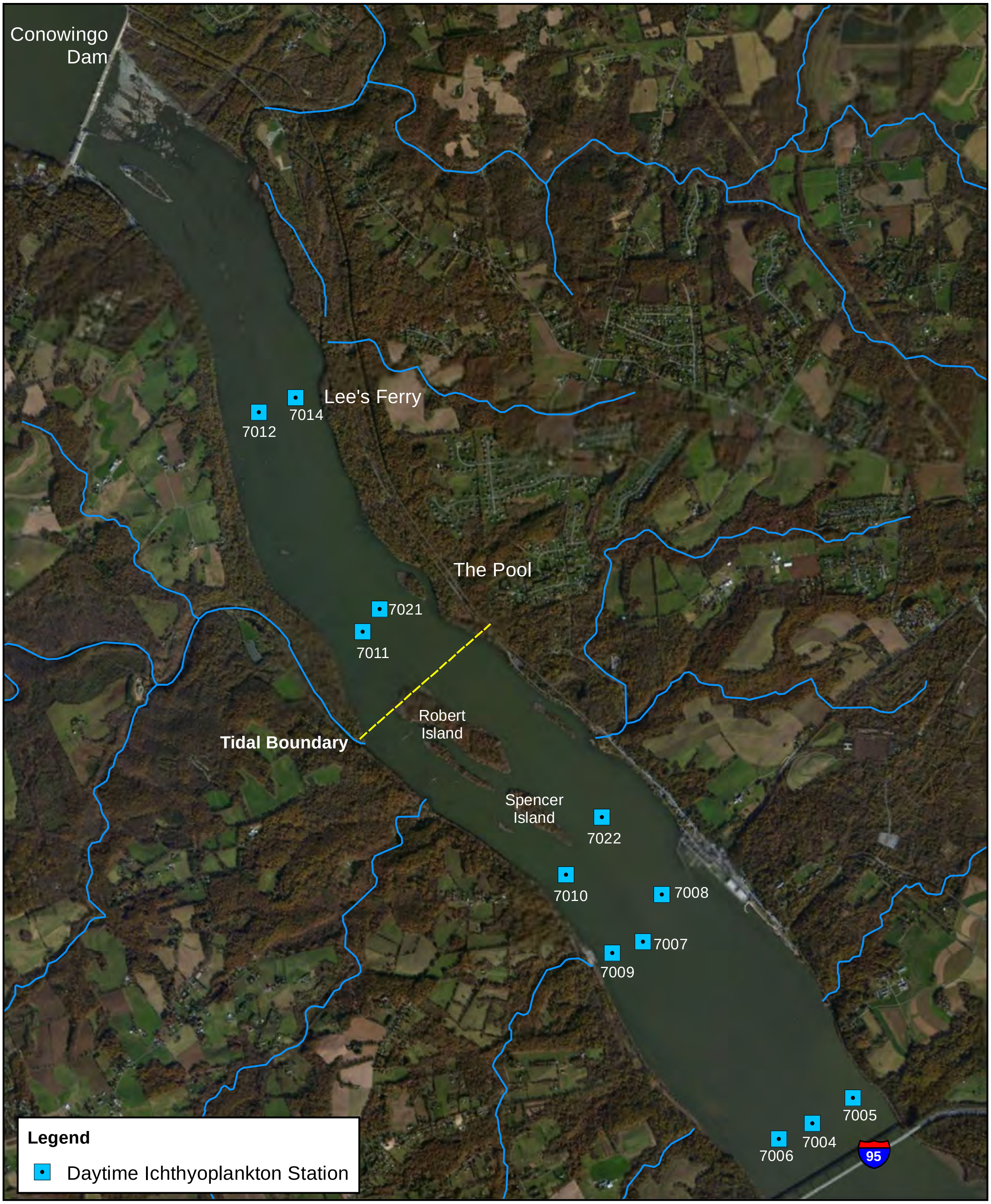
***1982-84 data taken from RMC, 1985a-c**

TABLE 4.5-1: TOTAL DENSITY (NUMBER/100M^3) OF TIDAL VERSUS NON-TIDAL ICHTHYOPLANKTON COLLECTED IN LOWER SUSQUEHANNA RIVER, 2012.

	All	
	tidal	**non-tidal**
AMERICAN SHAD	0.69	0.78
HICKORY SHAD	16.28	15.90
RIVER HERRING	92.61	480.69
STRIPED BASS	0.08	0.00
WHITE PERCH	12.75	6.99
GIZZARD SHAD	318.6	154.2
CARP AND MINNOW FAMILY	1.57	1.25
GOLDFISH	0.02	0.00
COMMON CARP	2.25	4.00
WHITE SUCKER	1.65	3.60
SUNFISH FAMILY	0.01	0.71
LEPOMIS SPECIES	0.04	0.50
LARGEMOUTH BASS	0.00	0.04
ROCK BASS	0.02	0.00
TESSELATED DARTER	0.24	0.28
YELLOW PERCH	0.02	0.00
BANDED DARTER	1.25	0.59
ATLANTIC NEEDLEFISH	0.04	0.00
UNKNOWN	0.04	0.04

TABLE 4.5-2: AVERAGE DENSITY (NUMBER100M^3) FOR EACH LIFE STAGE BY INDIVIDUAL STATION DOWNSTREAM OF CONOWINGO DAM, 2012. LOCATIONS OF STATIONS SHOWN IN FIGURE 2.0-1.

	Station	Unknown	Eggs	YSL	PYSL	YOY	Total
AMERICAN SHAD	**7010**	0.00	0.00	0.00	0.00	0.00	0.00
	7011	0.00	2.56	0.00	0.00	0.00	2.56
	7012	0.00	0.00	0.00	0.00	0.00	0.00
	7014	0.00	0.00	0.00	0.00	0.00	0.00
	7021	0.00	0.57	0.00	0.00	0.00	0.57
	7022	0.00	**4.16**	0.15	0.00	0.00	**4.31**
RIVER HERRRING	**7010**	0.00	108.10	6.26	16.33	0.00	130.69
	7011	0.00	529.45	5.08	70.07	0.00	604.60
	7012	0.00	109.92	2.06	**119.17**	0.00	231.15
	7014	0.00	378.63	3.48	54.29	0.00	436.40
	7021	0.52	**611.33**	3.46	35.42	0.00	**650.73**
	7022	0.29	186.09	**7.48**	5.75	0.00	199.61
HICKORY SHAD	**7010**	0.00	**40.38**	**8.75**	0.00	0.00	**49.13**
	7011	0.00	29.79	6.57	0.00	0.00	36.36
	7012	0.00	9.50	0.88	0.00	0.00	10.38
	7014	0.00	5.60	0.40	0.00	0.00	6.00
	7021	0.00	8.53	2.38	0.00	0.00	10.91
	7022	0.00	5.18	1.02	0.00	0.00	6.20



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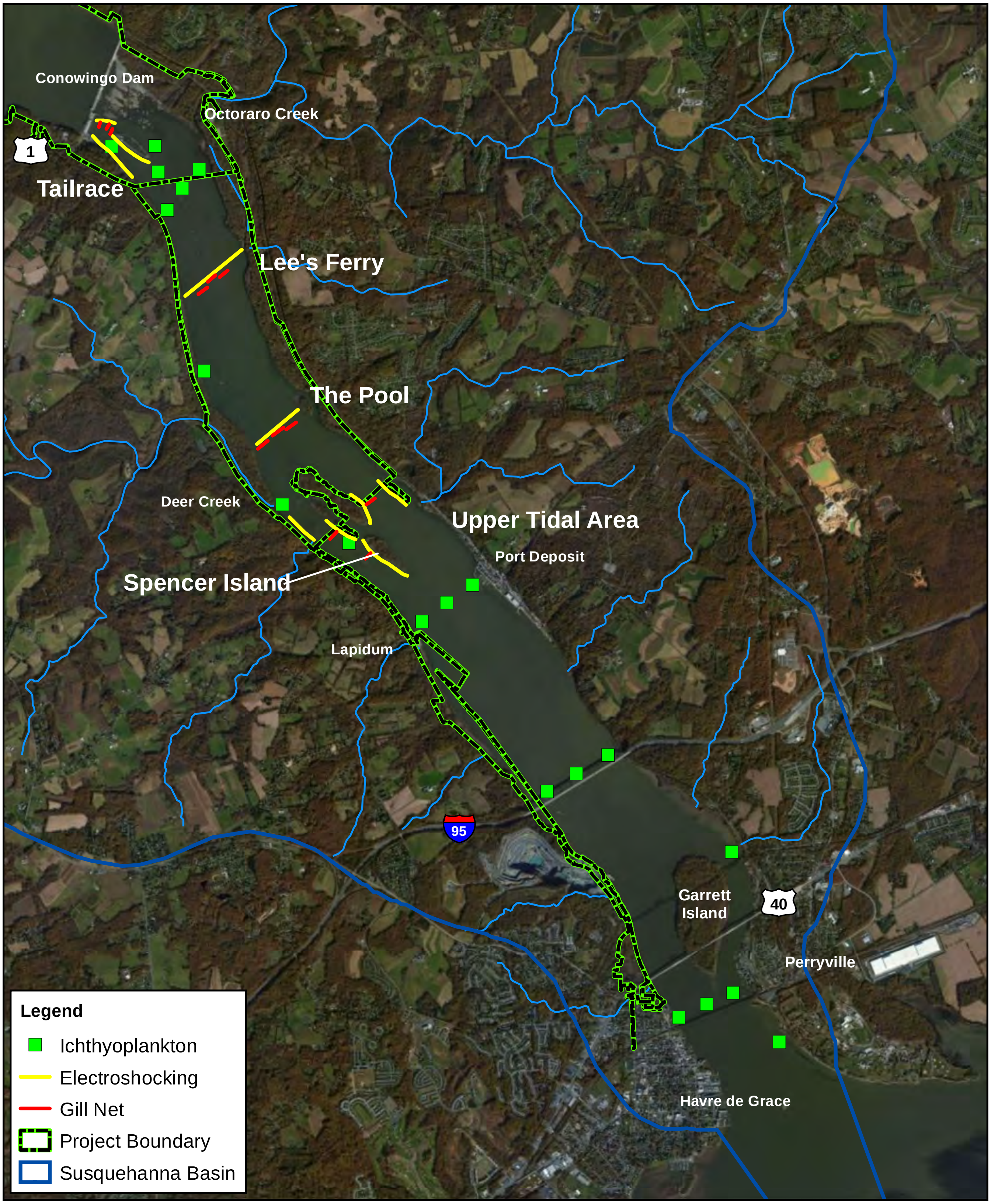
STUDY 3.21
CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

Figure: 2.0-1

1 inch = 0.7 miles

0 0.5 1 2 Miles

Path: X:\GISMaps\SSherman\Conowingo_321\IP_Day_2012.mxd



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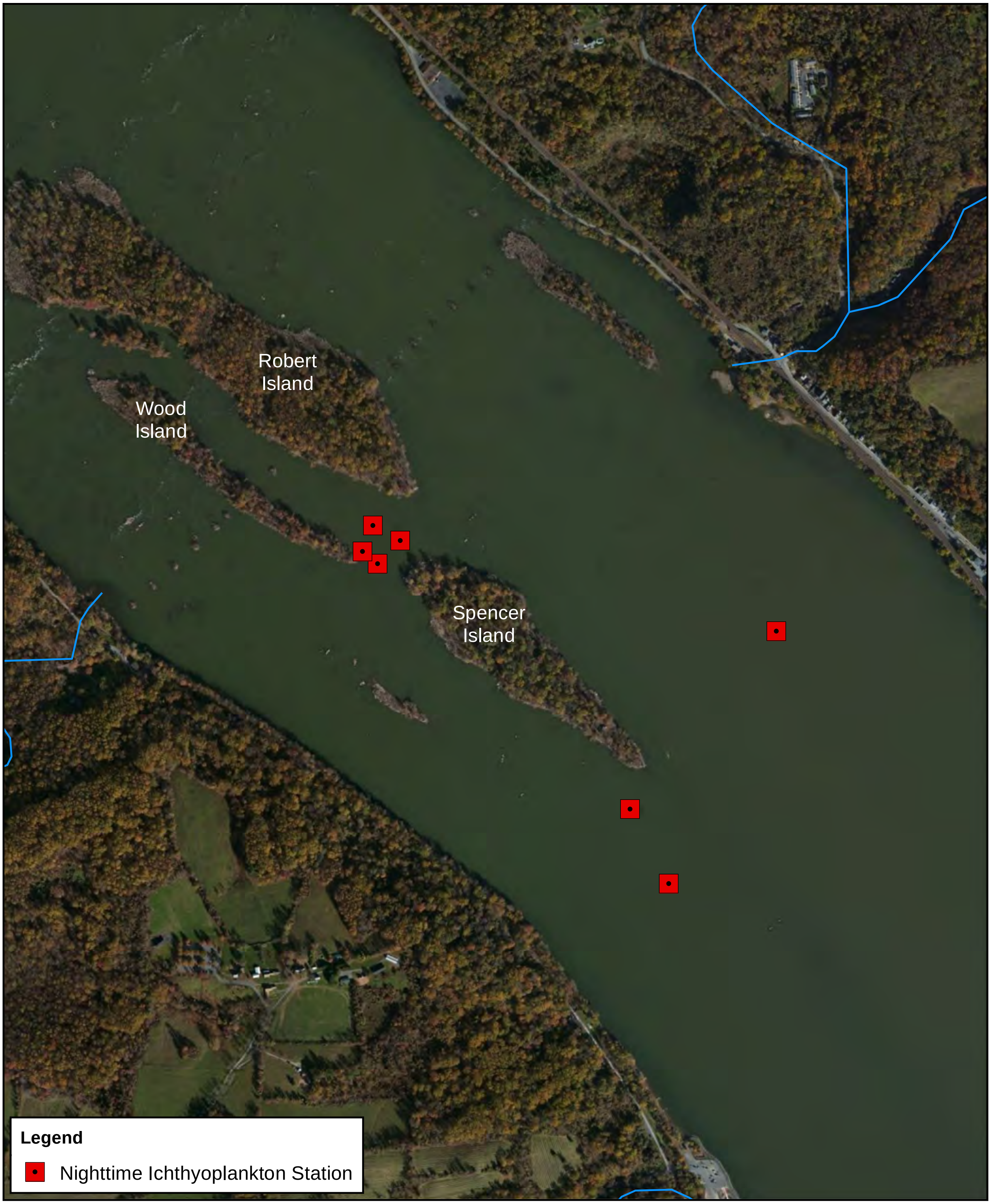
PROJECT NO. 405

Figure: 2.0-2

1 inch = 1.1 miles

0 0.5 1 2 Miles

Path: X:\GISMaps\SSherman\Conowingo_321\Figure2_0_2.mxd



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CONOWINGO HYDROELECTRIC PROJECT
PROJECT NO. 405

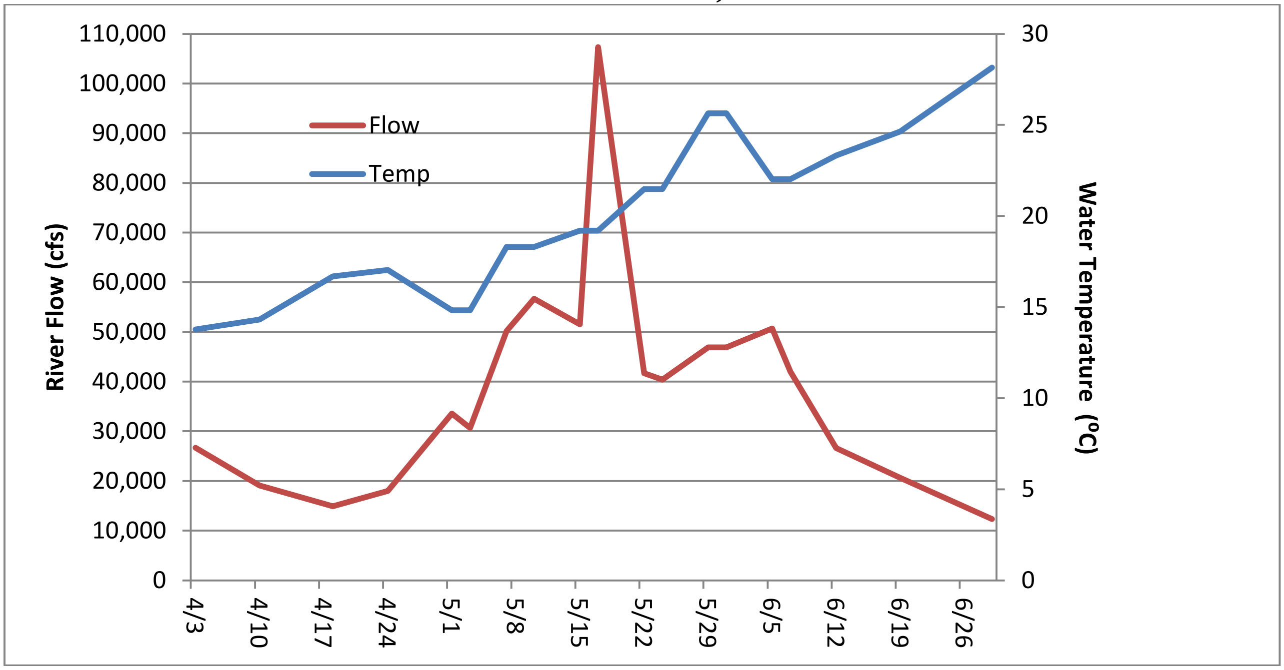
Figure: 2.0-3

1 inch = 0.2 miles

0 0.25 0.5 Miles

Path: X:\GISMaps\SSherman\Conowingo_321\IP_Night_2012.mxd

FIGURE 4.1-1: AVERAGE DAILY RIVER FLOW (CFS) AND WATER TEMPERATURE (^{0}C) DURING ICHTHYOPLANKTON SAMPLING DOWNSTREAM OF CONOWINGO DAM, APRIL 3 – JUNE 29, 2012.



*Average daily river flow provided by Holtwood Hydroelectric Project

APPENDIX A-LABORATORY STANDARD OPERATION PROTOCALS

CONOWINGO HYDROELECTRIC PROJECT ICHTHYOPLANKTON IDENTIFICATION STANDARD OPERATING PROCEDURES

1.0 Sorting and Identification

All fish eggs and larvae are removed (sorted) from the total material collected in each discrete sample, identified to the lowest possible taxonomic category (generally genus and species), and enumerated by life stage. If a specimen is damaged, or belongs to a group or stage which has not been adequately described to make a conclusive assignment to a species, it is enumerated and assigned to a higher taxonomic category (e.g. genus, family).

Larvae of American shad (*Alosa sapidissima*), hickory shad (*A. mediocris*), gizzard shad (*Dorosoma cepedianum*), blueback herring (*A. aestivalis*) and alewife (*A. pseudoharengus*) are morphologically similar and are difficult to identify to the species level. These clupeids are assigned to taxonomic categories using the characteristics in Table 1. American shad are distinguishable from other species using these characteristics. Hickory shad are difficult to differentiate until after the anal fin develops and some early stage individuals may be grouped with *Alosa* sp. Gizzard shad can be differentiated in the yolk-sac stage but in the post yolk-sac stage some individuals may be grouped with Clupeidae. Alewife and blueback herring cannot be readily differentiated as many individuals have myomere counts that are intermediate to the ranges presented in Table 1. These individuals will be grouped as *Alosa* sp. Life stages will be defined as egg, yolk sac larvae, post yolk sac larvae, and juvenile. A reference collection is made for the species and life stages collected. References used in the identification of ichthyoplankton are Fahay (2007), Lippson and R. L. Moran (1974), Mansueti and Hardy (1967) and Scotton (1973).

2.0 Subsampling

Samples with extremely high numbers of ichthyoplankton are subsampled in the lab with a Motoda plankton splitter according to established and statistically reliable protocols. If splitting a sample is appropriate, a minimum of 200 eggs and 200 larvae are sorted and identified from the subsample. Larger fish that are removed from the whole sample before splitting and kept separate from ichthyoplankton sorted from the sample after splitting, are labeled to show they represent the whole sample.

Subsampling due to large quantities of vegetative or inorganic material in the sample occurs when ichthyoplankton densities are low and more than 600 milliliters of settled volume of solids occurs in the sample. Under these circumstances, the minimum fraction analyzed is that fraction that contains 300 ml of settled material, usually a ½ split.

3.0 Quality Control

All laboratory sorting, fish identification and enumeration is subject to a standard and appropriate quality assurance/quality control review following the appropriate continuous sampling plan (CSP-1). Based on the anticipated number of samples, each analyst has their first eight samples in a row reinspected and then one out of seven randomly selected samples is reinspected. The acceptable error rate for an individual sample, sorted or identified is 10%. Quality control logs are maintained, documenting the samples analyzed, the samples selected for reanalysis according to the QC plan, the results of the QC analysis, and any corrective action performed. All QC logs will be 100% inspected monthly by the Laboratory Supervisors.

Table 1. Meristic characters used to differentiate clupeids in the study area.

Species	Pre-anal Myomeres	Post-anal Myomeres	Total Myomeres	Comments
American shad	41-47	10-16	55-57	Can be differentiated
Hickory shad	36-40	4-9	40-49	Difficult to differentiate until after anal fin is developed
Gizzard shad	43-44	3-8	47-51	PYSL difficult to differentiate
Alewife	40-41	5-9	46-50	Grouped as *Alosa* sp. (river herring)
Blueback herring	44-45	1-6	46-49	Grouped as *Alosa* sp. (river herring)

REFERENCES

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