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Early Life History of Northern Pike in Artificial Wetlands of Conesus Lake, New York

by James V. Morrow, K. Jack Killgore, Gary L. Miller



June 1995 – Final Report

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U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
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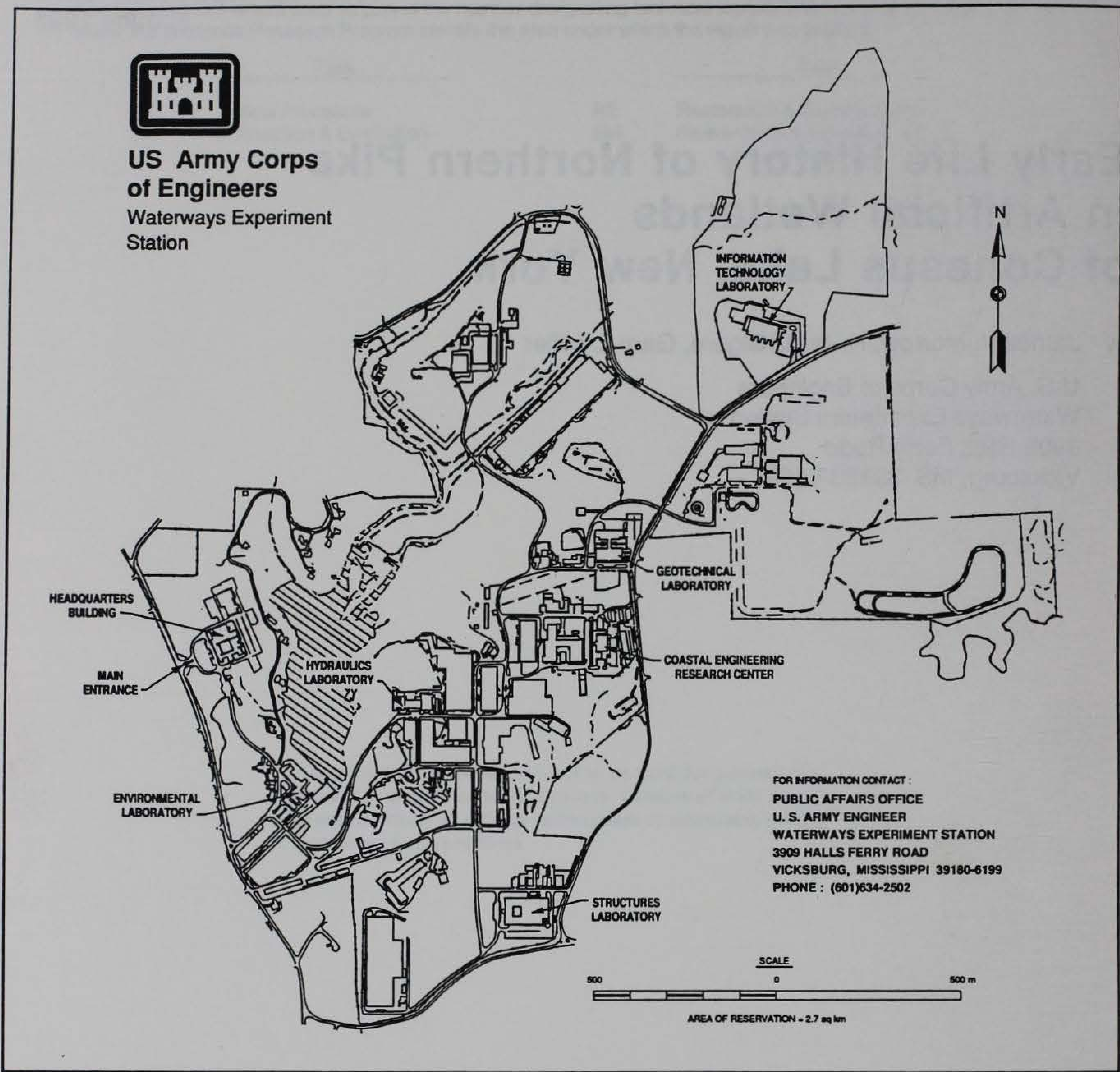

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Fisheries Habitat

Early Life History of Northern Pike in Artificial Wetlands of Conesus Lake, New York (TR WRP-SM-6)

ISSUE:

Many species of fishes use wetlands as spawning and rearing habitat. Conservation and creation of wetlands help maintain integrity of fish populations dependent on these habitats. However, artificial wetlands may not duplicate natural ecological conditions. Success criteria must be based on comparative studies between natural and artificial wetlands and related to early life history of a target fish species. Development of proper management criteria is necessary.

RESEARCH:

Northern pike reproductive success was compared between artificial and natural wetlands. A variety of techniques, including light traps, trap/dip nets, and electroshocking, were used to sample fishes in each wetland site and in transitional areas between wetlands and deepwater habitats. Abundance and size of fish were compared between wetlands. Dispersal strategies were evaluated according to abiotic and biotic factors.

SUMMARY:

Abundance and size of larval northern pike were greater in artificial than natural wetlands. Adult northern pike enter artificial wetlands during early spring and broadcast eggs over available substrate. Eggs are adhesive and attach to flooded vegetation. Larvae remain attached to vegetation for 7 to 10 days after hatching. Larvae are 6.5 to 8 mm total length at hatching, grow approximately 1 mm per day, and begin to emigrate from the spawning wetland at sizes as small as 14 mm. At 30 mm total length, most larval pike have emigrated from spawning wetlands and reside in transitional areas between wetlands and lacustrine habitat. The primary problem with these artificial wetlands is depositional areas that degrade spawning habitat and create obstacles to emigrating larvae.

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Preface

The work described in this report was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE), as part of the Stewardship and Management Task Area of the Wetlands Research Program (WRP). The work was performed under Work Unit 32766, "Wetland Stewardship and Management Demonstration Areas," for which Mr. Chester Martin was Technical Manager. Ms. Denise White (CECW-ON) was the WRP Technical Monitor for this work.

Mr. Dave Mathis (CERD-C) was the WRP Coordinator at the Directorate of Research and Development, HQUSACE; Dr. William L. Klesch (CECW-PO) served as the WRP Technical Monitor's Representative; Dr. Russell F. Theriot, Environmental Laboratory (EL), U.S. Army Engineer Waterways Experiment Station (WES), was the Wetlands Program Manager. Mr. Martin, Ecological Research Division (ERD), EL, was the Task Area Manager.

The report was prepared by Mr. James V. Morrow, University of Mississippi; Mr. K. Jack Killgore, WES; and Dr. Gary L. Miller, University of Mississippi. The work was performed under the direct supervision of Mr. K. Jack Killgore, and under the general supervision of Dr. Edwin A. Theriot, Chief, Aquatic Ecology Branch, Dr. Conrad J. Kirby, Chief, ERD, and Dr. John W. Keeley, Director, EL.

Numerous individuals contributed to this study. Logistical and technical support were provided by Dr. William Hallahan, Nazareth College, Rochester, NY, and Messrs. William Abraham and Dave Olsowsky of the New York Department of Environmental Conservation. Field assistance was provided by Mr. Brett Schneider and Ms. Rachael Alexander, Nazareth College, and Dr. James P. Kirk, Mr. Erick Nelson, and Mr. Larry Sanders, WES.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

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1 Introduction

Conesus Lake, the westernmost of New York's Finger Lakes, is located approximately 35 km south of Rochester, NY. Wetlands adjacent to Conesus Inlet and the south end of Conesus Lake flood annually during spring thaw. These seasonally flooded wetlands provide important spawning areas for northern pike (*Esox lucius*) (Forest, Wade, and Maxwell 1978). A flood control project implemented in spring 1989 reduced the magnitude of spring floods and subsequently reduced amount of spawning habitat. As mitigation for this loss, the U.S. Army Corps of Engineers in cooperation with the New York Department of Environmental Conservation (NYDEC) constructed wetlands adjacent to Conesus Inlet specifically for northern pike spawning and rearing.

Wetland construction is often used to enhance northern pike populations in areas where their natural spawning habitat has been altered (Forney 1968; Kleinert 1970; Fago 1977). However, success of this technique, measured by reproductive success, varies within and among wetlands (Forney 1968; Kleinert 1970). Spawning habitat for northern pike is usually created by damming inlet streams (Franklin and Smith 1963; Forney 1968; Threinen 1969; Kleinert 1970; Fago 1977). An elevation difference upstream and downstream of the dam occurs that pike must overcome to gain access to the wetland. Adult northern pike enter the wetland through fish ladders (Franklin and Smith 1963), are trapped at the dam spillway and manually placed in the spawning marsh (Forney 1968), or are trapped elsewhere in the lake and moved to the spawning wetland (Kleinert 1970; Fago 1977). The Conesus Lake wetlands were created by lowering ground levels below maximum lake level. This created wetlands that flood during high-water periods of spring thaw, giving adult northern pike free access and thus eliminating fish passage problems.

Objectives of this study were to (a) describe early life history of northern pike in artificial and natural wetlands at Conesus Lake, (b) compare reproductive success of northern pike between artificial and natural wetlands, and (c) recommend design and management options for artificial wetlands that can potentially improve reproductive success of northern pike.

2 Early Life History of Northern Pike

Northern pike spawn in spring approximately at ice breakup (Becker 1983). Eggs are deposited on vegetation in shallow-water habitats. Water temperatures in shallow wetlands increase rapidly compared with deepwater habitats, allowing eggs to hatch early compared with other fishes (Wootton 1990). Newly hatched larvae adhere to vegetation using a sucker-type membrane on the top of the head (Becker 1983). Two developmental stages have been recognized for larval northern pike: prolarval and alevin (Franklin and Smith 1963). The prolarval stage extends from hatching until active feeding begins. The alevin stage extends from the time larval northern pike are actively feeding until they are 35 mm total length, at which time pike have the adult body form and are classified as juveniles (Franklin and Smith 1963). Larval northern pike initially feed on zooplankton but rapidly shift to insect larva, amphipods, and small fishes (Wootton 1990). Hunt and Carbine (1951) found northern pike greater than 50 mm to be almost exclusively piscivorous. Others, however, found invertebrates to be an important component in diets of pike greater than 80 mm (Fago 1977; Derksen and Gillies 1985).

Emigration from spawning grounds extends from 10 days after hatching, at a mean length of 19 mm (Hunt and Carbine 1951) to the following autumn when pike are greater than 150 mm (Derksen and Gillies 1985). Hunt and Carbine (1951) suggested that light intensity was a primary factor causing emigration at the larval stage. However, Forney (1968) could not correlate emigration with sunlight intensity or amount of water flow from the spawning wetland. Franklin and Smith (1963) suggested that physiological changes triggered emigration when pike reach a size of approximately 20 mm. Some pike apparently do not leave the wetlands as larvae but remain until deteriorating water quality in late spring/early summer (Hunt and Carbine 1951) or early fall (Derksen and Gillies 1985) prompts emigration as juveniles.

Many fishes are cannibalistic and conspecifics are a source of high quality food for these fishes (Meffe and Crump 1987). Intraspecific aggression among larval northern pike may affect their survival on, and emigration from, spawning wetlands. Laboratory studies show that larval northern pike are aggressive and cannibalistic (Ivanova and Lopatko 1983; Giles, Wright, and Nord 1986). Intracohort cannibalism of larval and juvenile northern pike begins at lengths of 19 to 23 mm (Hunt and Carbine 1951; Giles, Wright, and Nord 1986; Wright and Giles 1987) and was found to be the major cause of mortality of pike in laboratory experiments (Giles, Wright, and Nord 1986) and experimental ponds (McCarraher 1957; Wright and Giles 1987). Hunt and Carbine (1951) speculated that intracohort cannibalism could be a major cause of mortality of larval pike in spawning grounds under certain conditions. Others, however, found cannibalism in spawning grounds to be low (Franklin and Smith 1963; Derksen and Gillies 1985).

3 Study Area

Conesus Lake is 12.6 km long by 1.34 km wide and has a maximum depth of 20.2 m and a surface area of 1,290 ha. (Forest, Wade, and Maxwell 1978). Conesus Lake is fed by several streams. The largest of these is Conesus Inlet, which has a mean flow of 0.90 m^3/sec and flows into the south end of the lake (Forest, Wade, and Maxwell 1978) (Figure 1).

Commercial and residential development occurs along the shoreline of the lake. Shoreline flooding, especially during the spring thaw, prompted the U.S. Army Corps of Engineers to implement a lake level management plan in spring 1989 to stabilize water levels. This plan included widening Conesus outlet and installing a larger water-control structure that was designed to maintain water levels below 249.6 m above mean sea level (amsl).

In 1990, as mitigation for the lake level management plan, the U.S. Army Corps of Engineers funded construction of three wetland ponds adjacent to Conesus Inlet totaling 3.7 ha. These artificial wetlands are designated A-1, A-2, and A-3 for this study (Figure 2). Each wetland was designed to have one outlet to Conesus Inlet with a riser-board water-control structure capable of maintaining interior water levels at 249.6 m amsl. Wetlands range in depth from 15 to 46 cm, increasing gradually from the levees to the water-control structure. The minimum top elevation of the levees is 249.6 m amsl, which should insulate the wetlands from the surrounding watershed. However, water-control structures and some sections of the levees are submerged during high flows. This problem is most pronounced in A-3, which is farthest upstream. In addition, muskrat activities have lowered parts of all levees below 249.6 m amsl. These design problems make management of water levels within the wetlands difficult.

In fall 1991, the NYDEC constructed a 0.32-ha pond just south of the wetlands constructed by the U.S. Army Corps of Engineers. This wetland is designated A-4 for this study (Figure 2). A-4 is located at a higher elevation than the other wetlands, so levees were not required. A-4 was constructed by lowering ground levels until the bottom of the pond was 249.6 m amsl at the end distal to Conesus Inlet, sloping gradually to 249.0 m amsl at the outlet. Because of budget constraints, A-4 was not equipped with a water-control structure. Water levels rise and fall with those of Conesus Inlet.

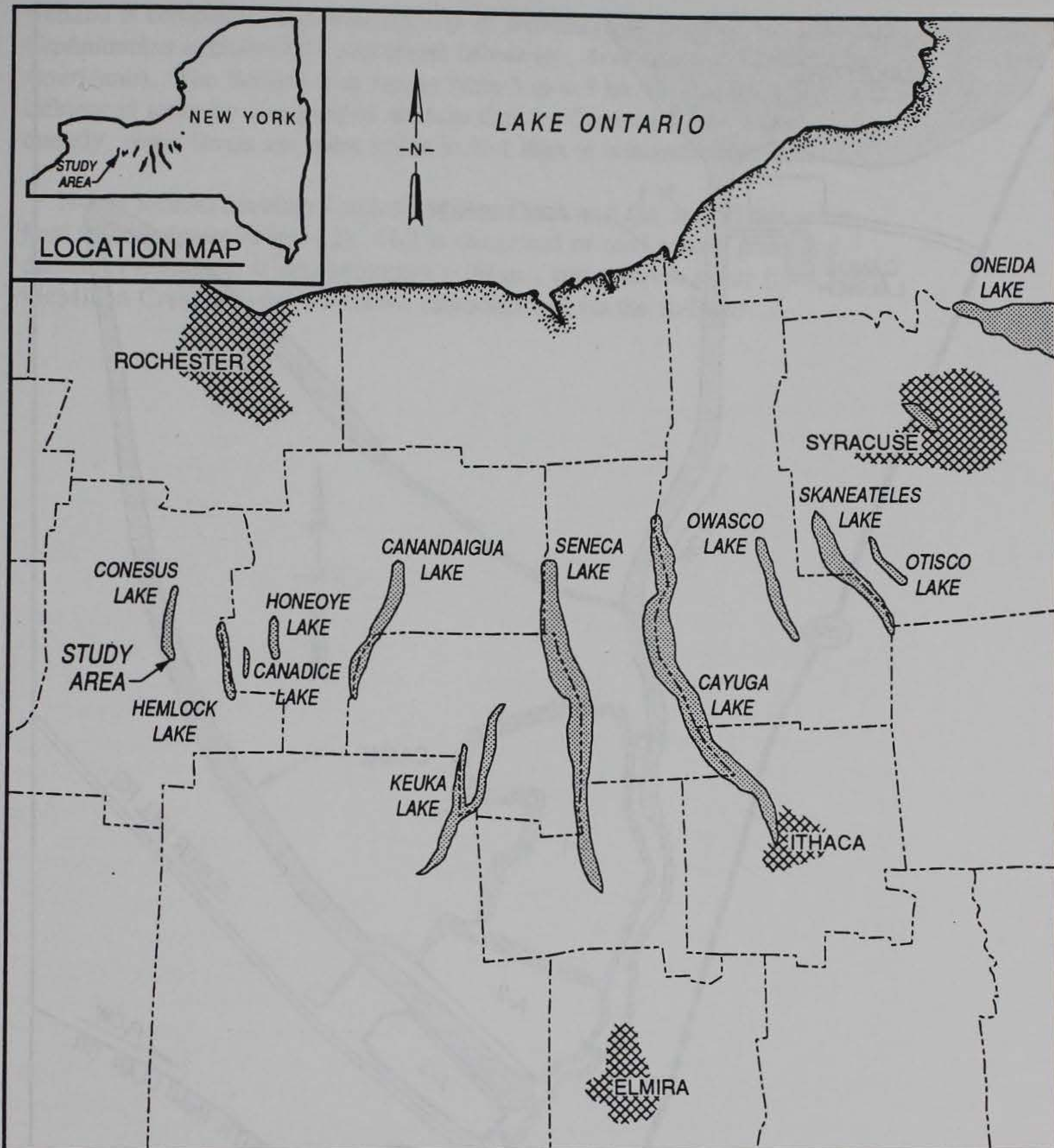

Figure 1. Finger lakes region of New York State

All artificial wetlands were planted with reed canary grass (*Phalaris arundinacea*). The grasses were well established in A-1, A-2, and A-3 at the beginning of the study in spring 1992. However, grasses in A-4 did not become well established until spring 1993.

The only natural wetlands still available to northern pike are located at the south end of Conesus Lake adjacent to Conesus Inlet. Two natural wetland sites are designated N-1 and N-2 for this study (Figure 2). N-1 is located between the most downstream artificial wetland (A-1) and the main lake. This

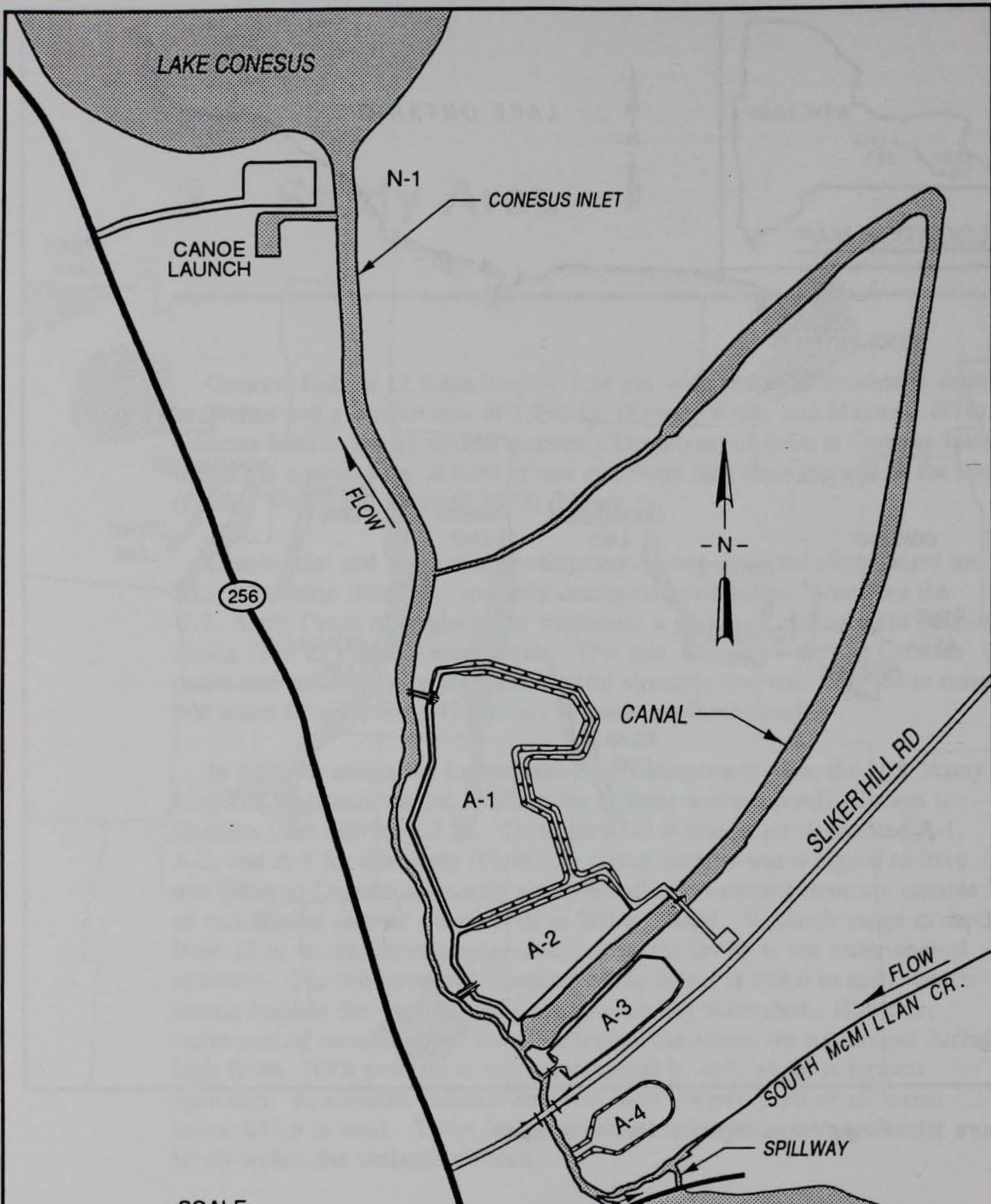

Figure 2. **Natural and artificial wetlands associated with Conesus Lake, New York**

wetland is composed of grasses (mostly *P. arundinacea*), shrubs (*Salix* sp. and *Cephalanthus occidentalis*), and forest (*Alnus* sp., *Acer* sp., and *Fraxinus americana*). The flooded area ranges from 3 to 4.5 ha. Water level of N-1 is influenced more by elevation of the lake than by Conesus Inlet. Consequently, water levels are more stable in N-1 than in wetlands upstream.

N-2 is located between South McMillan Creek and the dam of the waterfowl impoundment (Figure 2). N-2 is composed of reed canary grass and cattails (*Typha* sp.), is approximately 0.30 ha., and receives water from South McMillan Creek and the waterfowl impoundment via the spillway.

4 Methods

For the purposes of this study, northern pike are considered to be larval from hatching until they reach a total length of 35 mm. Larval northern pike are further divided into prolarval and alevin. The prolarval stage lasts from hatching until development has progressed enough for active feeding (approximately 13 mm). The alevin stage lasts from the end of the prolarval stage until pike have the mature form of an adult (approximately 35 mm).

Trap/Dip Net

Larval and juvenile northern pike were collected in wetlands of Conesus Lake using a trap/dip net combination described by Forney (1968). This method uses a rectangular trap 91 cm long, 45 cm wide, and 55 cm tall, with an open top and bottom. The trap was pushed into the sediments enclosing larval pike within four walls. A dip net was then used to remove all larval fishes from the trap. Each trap/dip net sample represented an area of 0.41 m^2; densities of pike were expressed on a square meter basis. Ten trap/dip net samples were taken in each wetland on 25 April, 8 May, and 2 June 1992. All samples were preserved in 10-percent formalin. In the laboratory, total length of northern pike was measured to the nearest millimeter, stomachs were removed, and food items identified. Density and mean length of pike between natural and artificial wetlands were compared using the GLM procedure with Tukey's studentized ranged test and an α = 0.05 (SAS Institute 1985). Grasses were not established in A-4 at the beginning of the study; therefore, data from A-4 were excluded from density comparisons.

Light Traps

Larval and juvenile pike were captured in the wetland sites and in Conesus Inlet with light traps (Killgore 1991). Light traps were constructed of clear Plexiglas and measured 30.5 by 30.5 by 16.0 cm. A Cyalume 12-hr, yellow chemical lightstick was placed inside the trap to attract larval fish. Light traps were set near sunset and retrieved the following morning. Abundance was expressed as numbers/trap night.

Spring 1992

Light traps were used in 1992 to determine if larval and juvenile northern pike could be collected with this method. On 9 May, one light trap was set in A-1 and one in A-2. On 10 May, one trap was set in N-2 and one just north of the A-1 levee near Conesus Inlet. On the nights of 26 May, 27 May, and 28 May, three traps each were fished in N-1 and A-1, A-2 and A-3, A-4 and N-2, respectively.

Spring 1993 and Spring 1994

Light traps were deployed in each wetland site and in Conesus Inlet during spring 1993 and 1994. Number of traps deployed in each site on each sampling date are given in (Table 1). Several comparisons were made on each sampling date. Pike abundance and length were compared between natural and artificial wetlands. Pike abundance and length were compared between wetlands and Conesus Inlet to evaluate emigration. Mean length was compared between pike captured in wetlands and pike captured in Conesus Inlet to evaluate size specific class emigration patterns. All comparisons between means were performed using the GLM procedure with Tukey's studentized range test and an α = 0.05 (SAS Institute 1985).

Table 1
Number of Light Traps Deployed in Wetland Sites and Conesus Inlet on Each Sampling Date During Spring 1993 and 1994

	Wetland Sites						
Date	A-1	A-2	A-3	A-4	N-1	N-2	Inlet
26 April 1993	3	3	3	3	3	3	2
13 May 1993	3	3	3	3	3	3	2
14 May 1993	3	3	3	3	3	3	2
2 June 1993	3	3	3	3	3	3	3
23 April 1994	2	2	2	2	2	2	3
26 April 1994	3	3	3	3	3	3	3
30 April 1994	3	3	3	3	3	3	4
3 May 1994	3	3	3	3	3	3	4
6 may 1994	3	3	3	3	3	3	6
9 May 1994	3	3	3	3	3	3	6

Electrofishing

On 1 and 2 June 1993, fishes were collected in wetland sites, Conesus Inlet, and along the south edge of Conesus Lake with a Smith Root Type VIII-A backpack electrofisher. Each sample consisted of approximately 300 sec of shocking along a transect. Three transects were made in each wetland, three were made along the south edge of Conesus Lake, and four were made in Conesus Inlet. All fishes collected were identified and measured. Juvenile northern pike were preserved in 10-percent formalin and transferred to the laboratory. In the laboratory, total length of juvenile northern pike was measured to the nearest millimeter, stomachs were removed, and food items identified. Mean length of pike and number of pike captured per transect were compared between wetlands and Conesus Inlet. Means were compared with the GLM procedure and Tukey's studentized range test with an $\alpha = 0.05$ (SAS Institute 1985). To determine if electrofishing catches of pike in Conesus Inlet were dependent on location, transects were numbered 1 (downstream) through 4 (upstream), and regressed against number of pike captured per transect using the GLM procedure (SAS Institute 1985).

Visual Observations

Visual observations of pike behavior were conducted to determine at what size larval pike begin to move, extent of intraspecific interaction in spawning wetlands, and at what size interactions begin. Two methods were used. First, pike were captured in wetlands or in Conesus Inlet with an aquarium net. Two pike were placed in a 20-ℓ circular arena and observed for 5 min. Movements and interactions between pike were counted and described and pike were measured to the nearest 0.5 mm and released. Fifteen pairs of pike were observed between 25 April and 9 May 1994. Second, an observer located a pike in a wetland habitat, observed it for 5 min, and recorded distance moved and encounters with other pike. An encounter was defined as an unobstructed, nearest-neighbor distance of 30 cm. At the end of 5 min, the pike was captured, measured to the nearest 0.5 mm, and released. If capture was not possible, length was visually estimated. One hundred eight pike were observed in this manner between 26 April and 9 May 1994. In addition, qualitative observations were made while other work was being performed.

5 Results

Trap/Dip Net

Larval northern pike collected on 25 April were in the prolarval stage with prominent yolk-sacs and underdeveloped mouths and pectoral fins; based on stomach analysis, they had not begun to feed. Larval northern pike were captured in all artificial wetlands on 25 April, including A-4 that lacked vegetation. However, density was low ($\bar{x}$ = 2.47/m^2) in A-4 (Table 2). Excluding A-4, larval northern pike densities were higher in artificial wetlands ($\bar{x}$ = 29.7/m^2) than in natural wetlands ($\bar{x}$ = 11.6/m^2) (F = 5.72, P = 0.02; Table 1). Mean total length of northern pike captured in artificial wetlands ($\bar{x}$ = 11.1 mm) was greater than those captured in natural wetlands ($\bar{x}$ = 10.7 mm) (F = 6.81, P = 0.01; Table 3).

Table 2
Density of Northern Pike (pike/m^2) for Each Wetland on 25 April 1992 and 7-9 May 1992

	25 April		7-9 May	
Wetland	Pike/m^2	S.D.	Pike/m^2	S.D.
A-1	33.8	32.9	4.4	4.7
A-2	19.8	30.5	4.7	2.9
A-3	35.1	27.7	2.8	3.4
A-4	2.5	2.4	2.5	3.5
N-1	5.2	8.9	1.8	2.7
N-2	18.0	24.9	9.6	6.6

Larval northern pike captured during 7-9 May 1992 were alevins, i.e., well-developed mouths and no yolk-sacs. Seventy-six of seventy-seven stomachs examined were full and contained mostly zooplankton and aquatic insects. One individual had eaten another larval pike (Table 4). Mean total length of larvae was 17.5 mm; length of those captured on the artificial wetlands ($\bar{x}$ = 19.0 mm) was greater than those captured on natural wetlands

($\bar{x}$ = 15.2 mm) (F = 26.0, P < 0.01; Table 3). No differences in pike density were detected between natural and artificial wetlands during 7-9 May. However, high numbers of larvae observed in Conesus Inlet indicated emigration from the wetlands. Overall pike densities declined between 25 April and 7-9 May (F = 18.1, P < 0.01; Table 2).

Sixty trap/dip net samples taken on 2 June 1992 yielded only two pike with lengths of 53 and 51 mm. Stomach analysis of these two fish is included in Table 4.

Table 3
Mean Total Length of Northern Pike Larva Collected on 25 April and 7-9 May 1992

	25 April			7-9 May		
Wetland	N	Length, mm	S.D.	N	Length, mm	S.D.
A-1	119	10.8	1.67	16	18.1	3.2
A-2	65	11.8	1.25	16	19.0	3.1
A-3	120	10.9	1.11	9	19.1	3.6
A-4	9	11.7	1.39	9	20.2	3.2
N-1	19	9.2	2.43	6	14.5	1.2
N-2	69	11.0	0.88	32	15.3	4.1

Note: N = Number or sample size.

Table 4
Food Items from Larval and Juvenile Northern Pike Captured in the Spawning Grounds, May 1992

	Number of Food Items	
Food Type	7-9 May	26 May
Daphnia	79	82
Chydorous	465	0
Copepodia	1,343	0
Ostracoda	29	0
Chironomid	100	5
Insect larva	11	0
Corxidae	0	6
Pike larva	1	0

Note: Number = 76 larval pike during 7-9 May, 2 juvenile pike on 26 May.

Light Traps

Spring 1992

Mean abundance of larval pike captured in light traps on 10 May was 7.3 (29 total fish collected in four traps). Mean length was 19.5 mm. Mean abundance of larval pike captured in light traps on 26-28 May was 0.77 (14 total fish collected in 18 light traps). Mean length was 56.4 mm.

Spring 1993

No larval fish were collected in light traps set in wetlands and Conesus Inlet on 26 April. Larval pike observed in the wetlands at this time were in the early prolarval stage and had not begun to swim freely and feed. Light traps set on 13 and 14 May captured larval northern pike at all sites. Pike abundance was higher in Conesus Inlet ($\bar{x}$ = 10.0) than in wetland sites ($\bar{x}$ = 1.25) ($F = 18.3$, $P < 0.01$; Table 5). Mean total length of pike captured in the inlet ($\bar{x}$ = 27.9 mm) was smaller than pike captured in wetlands ($\bar{x}$ = 32.0 mm) ($F = 8.9$, $P < 0.01$; Table 5). Mean length of pike captured at all sites on 13 and 14 May was 30.2 mm. Thirty-seven juvenile northern pike were captured in light traps on 2 June. Pike were captured in Conesus Inlet and all wetlands except N-1. Mean total length of juvenile pike captured in Conesus Inlet ($\bar{x}$ = 67.5 mm) was greater than those captured in wetlands ($\bar{x}$ = 53.9 mm) ($F = 26.82$, $P < 0.01$). Juvenile pike abundance was higher in the Inlet than in wetlands ($F = 10.46$, $P < 0.01$; Table 6).

Table 5
Mean Number and Mean Total Length of Larval Northern Pike Captured per Light Trap Night for 13 and 14 May 1993

Wetland	N	Number of Pike Captured per Trap Set	S.D.	Total Length	Total S.D.
A-1	6	1.83	1.47	30.1	5.28
A-2	6	1.00	0.89	36.3	7.67
A-3	6	1.17	1.17	28.7	3.55
A-4	6	1.67	2.25	37.4	3.84
N-1	6	0.50	0.54	21.0	2.64
N-2	6	0.17	0.41	24.0	--
Inlet	3	10.00[1]	13.08	27.9	3.42

Note: N = Number or sample size.
[1] Significantly greater than all others. $\alpha = 0.05$.

Table 6
Mean Number and Total Length of Juvenile Northern Pike Captured per Light Trap Night on 2 June 1993

Wetland	N	Number of Pike Captured per Trap Set	S.D.	Total	
				Length	S.D.
A-1	3	0.67	1.54	50.5	2.12
A-2	3	0.67	1.54	62.5	6.36
A-3	3	2.00	2.00	50.3	7.20
A-4	3	0.67	1.54	56.0	4.24
N-1	3	0.00	0.00	--	--
N-2	3	0.33	0.57	61.0	--
Inlet	3	8.00	10.39	67.5	7.83

Note: N = Number or sample size.

Spring 1994

No pike were captured in Conesus Inlet on 23 April. One 14-mm pike was captured in Conesus Inlet on 26 April, and on each successive sampling date, the number of pike per trap in Conesus Inlet increased (Table 7). Mean length of pike captured in the Inlet was greater than that of pike captured in the wetlands on 3 May (17.9 mm and 16.1 mm) ($F = 12.16$, $P < 0.01$), 9 May (17.3 mm and 16.2 mm) ($F = 17.85$, $P < 0.01$), and overall (17.2 mm and 15.9 mm) ($F = 46.11$, $P < 0.01$; Table 10). Overall, mean length of pike captured in artificial wetlands ($\bar{x} = 15.7$ mm) was greater than that of pike captured in natural wetlands ($\bar{x} = 12.1$ mm) ($F = 57.18$, $P < 0.02$). Mean number of pike captured per trap set was greater in artificial wetlands ($\bar{x} = 7.5$) than in natural wetlands ($\bar{x} = 0.85$) ($F = 7.79$, $P < 0.01$). Other fishes captured in light traps are listed in Table 8.

Electrofishing

Twenty-nine juvenile northern pike were captured by electrofishing on 1 and 2 June 1993. Juvenile northern pike observed while electrofishing were usually in small groups. Pike did not appear to be as susceptible to electrofishing as other fishes captured (i.e., mudminnows (*Umbra limi*), largemouth bass (*Micropterus salmoides*), and pumpkinseed (*Lepomis gibbosus*). More pike per transect were captured in Conesus Inlet ($\bar{x} = 6.0$) than in wetlands ($\bar{x} = 0.28$) ($F = 39.9$, $P < 0.01$; Table 9). No juvenile pike were captured

Table 7
Mean Abundance and Mean Lengths of Larval Northern Pike Captured in Light Traps, Spring 1994

Date	Pike Captured per Light Trap				Mean Length of Pike	
	Natural	Artificial	All Wetlands	Inlet	All Wetlands	Inlet
23 April	5.5	2.8	3.7	0.0	11.7	--
26 April	0.17[1]	3.8	2.6	0.33	14.5	14.0
30 April	0.50	8.8	6.0	2.7	15.2	16.5
3 May	0.33	6.9	4.2	7.2	16.1[2]	17.9
6 May	0.18	11.9	8.0	7.8	16.4	16.6
9 May	0.0	9.1	6.1	20.7	16.2[2]	17.3
All Dates	0.9[1]	7.5	5.3	8.4	15.9[2]	17.2

[1] Significant difference in number of pike captured in light traps between natural and artificial wetlands.
[2] Significant difference in mean length between pike captured in wetlands and pike captured in Conesus Inlet.

Table 8
List of Fish Species Captured in the Wetlands and in Conesus Inlet by Larval Light Trapping and Electrofishing

Species	Method of Capture	Life Stage	Habitat
Ambloplites rupestris	E	A	L I
Catostomus commersoni	L	L	A
Cyprinus carpio	L	L	A
Fundulus diaphanus	E L	A	A N
Hybognathus nuchalis	L	L	A N
Ictalurus melas	E	A	A
Labidesthes sicculus	L	A	I
Lepomis gibbosus	E	A	L I
Lepomis macrochirus	L	J	A N
Notemigonus crysoleucas	E L	A L	I A N
Notropis cornutus	L	L	A
Micropterus salmoides	E	A	I
Pimephales promelas	L	L	A
Scardinius erythropthalmus	E	A	N
Umbra limi	E L	A L	I A N

Note: Method of capture: E = Electrofishing, L = Light trapping. Life stage: A = Adult, J = Juvenile, L = Larval. Habitat: L = Lake edge, I = Conesus Inlet, A = Artificial wetland, N = Natural wetland.

Table 9
Mean Number and Total Length of Juvenile Northern Pike Captured per Electrofishing Transect on 2 and 3 June 1993

		Number of Pike		Total	
Wetland	N	Captured per 300 Sec	S.D.	Length	S.D.
A-1	3	0.67	1.54	77.0	0.00
A-2	3	0.00	0.00	--	--
A-3	3	0.00	0.00	--	--
A-4	3	1.00	1.73	57.7	12.50
N-1	3	0.00	0.00	--	--
N-2	3	0.00	0.00	--	--
Inlet	4	6.00	3.74	67.7	6.38

Note: N = Number or sample size.

or observed in wetlands N-1, A-2, or A-3. Juvenile pike were observed in A-4 although none were captured. Northern pike were neither captured nor observed along the south edge of Conesus Lake. The number of juvenile pike captured per transect increased upstream in Conesus Inlet ($F = 28.0$, $P < 0.01$).

Stomachs of 29 juvenile northern pike captured by electrofishing were examined (Table 10). Twelve stomachs contained identifiable food items and seventeen were empty or nearly empty. Of the 12 with identifiable food items, only 3 contained fish. Food items ranged from zooplankton to other juvenile pike. Although diets were diverse, individual pike appeared to select one type of prey. Other fish species captured by electrofishing are listed in Table 8.

Visual Observations

Five of fifteen pairs observed in arenas were less than 12 mm total length. These pike did not move or interact during the observation period. Four of the five pairs laid on the bottom. In the fifth pair, one fish laid on the bottom, and the other stayed at the surface in a head-up tail-down position, holding position with movements of the caudal fin. In 9 of the 10 pairs with members over 12 mm, at least one member moved continually around the arena, constantly running into the side. This continued for several minutes before the pike stopped and repeated the behavior going the opposite way around the arena. None of the pike over 12 mm laid on the bottom.

Table 10
Food Items Eaten by Juvenile Northern Pike Captured by Electrofishing on 2 and 3 June 1993

Pike	Length, mm	Food Items Found
1	58	One amphipod and four ephemeroptera larva
2	65	One amphipod and one ephemeroptera larva
3	66	Invertebrate parts
4	61	One segmented worm <20 mm
5	66	One juvenile pike <30 mm
6	80	One minnow <20 mm
7	63	Two damsel fly larva
8	62	One ephemeroptera larva and one cladocern
9	77	One minnow, 28 mm
10	72	Two damsel fly larval
11	52	Twenty-five chironomids
12	49	103 Daphnia, one ostracod, two copepods

Pike observed in the wetland moved an average of 1.08 m during the 5-min observation period. Directional changes during movement were very rare. Distance of movement was highly variable, with a range of 0 to 4.6 m and a standard deviation of 1.2. Distance moved could not be correlated with total length of pike between 13 and 22 mm. Ninety-five encounters with other pike were recorded. In 68 of these, neither pike showed any visible reaction. An aggressive reaction was observed in one encounter.

6 Discussion

Northern pike successfully spawned in the artificial wetlands of Conesus Lake during each year of this study. Larval northern pike collected in the trap/dip net combination on 25 April were in the prolarval stage, and very few eggs were collected. This suggests that egg deposition occurred in early April, and peak abundance of larval northern pike on the spawning grounds occurred in late April 1992. Densities of larval northern pike estimated at this time were within the range of densities observed or estimated in experimental ponds (McCarraher 1957), artificial spawning marshes (Forney 1968; Fago 1977), and natural areas (McCarraher 1972).

The trap/dip net data indicate that more pike hatch in artificial wetlands than in natural wetlands. Light trap data indicate that more larval pike reach the free swimming stage in artificial wetlands than in natural wetlands. Mean length of pike captured by the trap/dip net and in light traps was greater in artificial wetlands than in natural wetlands. This suggests that larval pike grow faster and/or hatch earlier in artificial wetlands. High density and fast growth of larval northern pike on artificial wetlands may be due to several factors. First, artificial wetlands do not have overhead cover in the form of shrubs and trees. This allows the shallow areas to warm rapidly compared with shaded areas in natural wetlands. Second, artificial wetlands are allowed to dry and are mowed annually or semiannually to discourage growth of cattails and woody vegetation and encourage growth of grasses to which pike eggs and larva can attach and avoid siltation.

Most larval northern pike emigrate from the spawning wetland soon after reaching the free-swimming life stage (Hunt and Carbine 1951; Franklin and Smith 1963). In Conesus Lake, pike begin to leave wetlands at sizes as small as 14 mm. Based on visual observations, 13-mm larval pike periodically swim in a straight line for several minutes at a time. This behavior was noted by Forney (1968). Pike probably continue this behavior until an outlet to the wetland is located (Forney 1968). Early emigration may be an adaptation to avoid competition with or predation by other larval northern pike.

An alternative dispersal strategy was also noted. Some pike apparently remain on the wetlands until they become fingerlings (50 mm), which was also reported from other studies (Hunt and Carbine 1951; Franklin and Smith 1963; Forney 1968). Wetlands may provide nursery habitat for a number of larval pike that either do not emigrate as alevins or migrate back to the wetlands as fingerlings. Invertebrates were important components in diets of northern pike up to 70 mm total length.

Larval northern pike were readily captured by light traps in Conesus Inlet during spring 1993 and 1994. Furthermore, abundance of juvenile northern pike captured by light traps and electrofishing during spring 1993 was greater in Conesus Inlet than in the wetlands or along the south end of Conesus Lake. Also, juvenile northern pike were concentrated in the upper reaches of Conesus Inlet. These observations suggest that Conesus Inlet is an important transition area for larval and juvenile northern pike moving from wetlands to the main lake.

Sediment deposition in the artificial wetlands is a problem. Crest elevation for levees around wetlands A-1, A-2, and A-3 is 249.6 m amsl. Conesus Inlet remains above 249.6 m amsl for much of the spring. This causes sediments to be deposited in the artificial wetlands. Sedimentation is particularly apparent in A-3. Because of a slight bend in Conesus Inlet and the canal between A-3 and A-2 (Figure 2), A-3 acts as a stilling basin during high flows. A noticeable amount of sedimentation occurred in A-3 between the 1992- and 1993-sampling seasons. Constructing levees with top elevations that equal or exceed the highest spring water levels would correct this problem.

Depositional areas have also created obstacles to fish passage. In 1993, a sandbar formed in Conesus Inlet across the mouth of the A-4 outlet channel. This created a barrier to emigrating larval and juvenile northern pike when water levels in the Inlet dropped, stranding them in the wetland. Larval pike were also stranded in A-4 because of an area of silt deposition adjacent to the wetland end of the outlet channel that is 5 to 10 cm shallower than the deepest part of the wetland. When water levels in Conesus Inlet drop below the level of this area, larval and juvenile pike are stranded in the shallow water of the wetland. In 1994, silt deposits also threatened to close off the outlet channel of A-2. All of these situations were corrected by manually removing enough deposits to provide a small channel to Conesus Inlet. Pike were observed using these channels, indicating that stranding had occurred.

Stranding of pike larvae was observed in N-2. Water elevation in N-2 can be manipulated by water releases from the waterfowl impoundment spillway. During springs 1992 and 1993, water elevation in N-2 remained high, and no apparent stranding of young pike was observed. However, water elevation in N-2 dropped below that of South McMillan Creek in spring 1994 so that by 25 April, larval northern pike were stranded in the wetland. Several adult walleyes (*Stizostedion vitreum*) were also stranded. These problems were eliminated the following day when NYDEC raised one board of the waterfowl impoundment spillway approximately 100 mm, which provided enough water for fishes to move into South McMillan Creek.

7 Design Recommendations

Northern pike spawning marshes should have the following characteristics:

a. No overhead cover in the form of trees or shrubs. Trees and shrubs will inhibit growth of grasses that provide spawning substrate for pike.

b. Approximately 75 to 90 percent of the wetland should have water depths of 150 to 450 mm during the spawning season. These areas should slope gradually from the edge of the wetland to the outlet to avoid stranding fish as water levels drop (Franklin and Smith 1963).

c. Ten to twenty five percent of the wetland should have depths greater than 450 mm. The shallow areas described above should slope gradually into these deeper areas. The deep areas will provide a transitional habitat between the grassy shallows and deepwater habitats. These areas will also provide a refuge for the pike as water levels drop and may be useful as spawning habitat in unusually dry years.

d. Adult northern pike should have access to the wetland from the time snow melts until 1 week after all spawning activity has stopped. This will give adult pike ample time to exit the wetland after spawning. If it is not feasible to build wetlands below normal high water level, a dam that impounds an existing stream or a dam in conjunction with pumping will be necessary to manage water levels. If a head difference greater than 0.20 m exists between the artificial wetland and adjacent deepwater habitat, then special structures may be necessary to allow adult northern pike to enter the wetland (Katopodis 1991). Problems of fish passage over low-head structures are discussed in (Morrow, Meyer, and Killgore, in preparation).

e. A channel should run from the wetland, through the water-control structure/outlet, into deepwater habitat. This will facilitate emigration of the last pike from the wetland when it is drained after the spawning/rearing season. Any silt plugs or sandbars that form and block this channel should be removed as part of a general maintenance program.

f. Levees should be slightly higher than high-water levels for a normal year. This will prevent excessive siltation and will increase the useful life of the wetland.

g. The wetland should have a water-control structure that will enable manipulation of water levels. Water should be held on the wetland for 8 to 12 weeks after spawning has ceased. However, larval pike should have unobstructed access to deepwater habitats from 1 week after hatching (2 to 3 weeks after spawning) through mid to late summer (Franklin and Smith 1963). The outlet can be relatively small—0.15 m wide and .075 m deep should be sufficient. Forney (1968) found that number of larval pike exiting through an outlet is not related to outlet discharge.

h. The wetland should be drained in mid or late summer to permit reestablishment of terrestrial vegetation (Franklin and Smith 1963). The wetland should be mowed at least every other year.

i. The wetland should be monitored regularly during the time eggs and larvae are present to ensure that water levels are adequate and that outlets to deepwater habitats are maintained.

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Reproductive success of northern pike was evaluated for artificial and natural wetlands adjacent to Conesus Lake, New York. Fishes were collected for 3 consecutive years during the spawning/rearing season (April – June). Larval and juvenile northern pike were collected in natural wetlands, artificial wetlands, and in Conesus Inlet. Mean abundance and mean length of pike were compared between these habitats.

Northern pike spawn in natural and artificial wetlands adjacent to Conesus Lake and Conesus Inlet. Mean abundance and mean length of larval northern pike were greater in artificial wetlands than in natural wetlands. Emigration from the wetlands into Conesus Inlet begins at sizes as small as 14 mm and is usually complete at a length of 30 mm. Northern pike were collected in Conesus Inlet as early as 6 April at sizes of 14 mm and as late as 2 June at sizes of 80 mm, indicating that Conesus Inlet is an important transitional habitat between spawning wetlands and Conesus Lake.

Artificial spawning wetlands for northern pike should be designed and managed to promote growth of grasses and sedges and inhibit growth of woody vegetation. They should flood in early spring and dry in late summer or early fall, but water levels should not fluctuate greatly during the spawning and rearing season. Larval and juvenile northern pike should have access to deepwater habitats from hatching until the wetlands dry.

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