Seasonal Presence and Movement of Fish Populations in the Tidal Reach of Quassaic Creek, a Hudson River Tributary (HRM 60): Documentation of Potamodromy, Anadromy, and Residential Components.

A Final Report of the 1996 Tibor T. Polgar Fellowship Program

Thomas R. Lake
Polgar Fellow
SUNY New Paltz
New Paltz, NY

and

Robert E. Schmidt
Supervisor
Simon's Rock College of Bard
Great Barrington, MA 01230

Lake, T.R., and R.E. Schmidt. 1997. Seasonal presence and movement of fish populations in the tidal reach of Quassaic Creek, a Hudson River tributary (HRM 60): Documentation of potamodromy, anadromy, and residential components. Section VII: 36 pp *In.* W.C. Nieder and J.R. Waldman (Eds). Final Reports of the Tibor T. Polgar Fellowship Program, 1996. Hudson River Foundation, NY.

Abstract

The majority of Hudson River biological research has been focused on the main artery of the river in an effort to better understand the population dynamics of economically important species such as Atlantic sturgeon (*Acipenser oxyrynchus*), striped bass (*Morone saxatilis*), and American shad (*Alosa sapidissima*). By comparison, relatively little is known of the tidal tributaries and how they relate to the river (Schmidt and Limburg 1996). This research investigated the relationship between the Hudson River and Quassaic Creek (a tidal tributary at approximately river mile 60) focusing on the presence and behavior of both resident and transient fish populations. For six months, from March 24 through September 26, 1996, intensive sampling was conducted in the tidal reach of Quassaic Creek up to the first impassable dam (~1.1 km). This began just prior to the major spring spawning season, included the late spring and summer young-of-the-year *(yoy)* nursery period, and concluded with the late summer-early fall migration of juvenile anadromous fishes from the Hudson. This study found 30 species of fish in Quassaic Creek, including four classifications of estuarine fishes: anadromous, catadromous, potamodromous, and residential. Quassaic Creek's major contribution to the Hudson estuary is as a spring spawning site. At least 15 species used Quassaic Creek, or the delta periphery, for spawning. There was a strong spawning run of alewives *(Alosa pseudoharengus)*, far exceeding previous estimates (Schmidt *et al.* 1994). There was also significant spawning activity for spottail shiners *(Notropis hudsonius)*, white perch *(Morone americana)*, and white suckers *(Catostomus commersoni)*. Summer sampling found *yoy* of 16 species indicating the use of Quassaic both as a spawning habitat and as a transitional nursery for fish spawned elsewhere.

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Introduction

Rivers tributary to the tidal Hudson estuary contribute about 20% of the freshwater entering the estuary (Cooper *et al.* 1988) and about 23% of the organic carbon input (Gladden *et al.* 1988). Unknown quantities of sediments, various pollutants, and insect biomass are also brought into the Hudson from these tributaries.

Hudson River tributaries often have spawning runs of anadromous and potamodromous fishes (Limburg and Schmidt 1990; Schmidt and Stillman 1994) that may contribute significantly to estuarine populations. Many of the Hudson River tributaries have barriers (Schmidt and Cooper 1995) which have reduced or eliminated access for migratory fishes.

Other than incidental observations, there is little information available on the composition of the fish communities inhabiting tributary mouths. Anderson (1988) defined the fish community in tidal Hudson River tributaries as consisting of American eels (*Anguilla rostrata*), pumpkinseeds (*Lepomis gibbosus*), golden shiners (*Notemigonus crysoleucas*), banded killifish (*Fundulus diaphanus*), bluegills (*Lepomis macrochirus*), and spottail shiners (*Notropis hudsonius*). His data were taken from C.L. Smith's (1985) observations but are point estimates that say little about seasonal or other changes that may occur over a year in tributary mouths.

The main purpose of this study was to document the composition of the fish fauna in the mouth of one tributary in the Hudson estuary. A secondary purpose was to differentiate among anadromous, potatmodromous, and resident components of the fish community.

Methods

Study area—Quassaic Creek is located at approximately river mile 60, which is very near, or at, the average summer upstream limit of the Hudson River "salt front" (~1-3 ppt salinity) in Newburgh, New York (Fig. 1). It is 3.2 km north of Moodna Creek, and directly across the river from Fishkill Creek, the two closest major Hudson River tributaries. The location of this tributary is ideal for documenting the presence of freshwater and brackish water fish fauna and investigating their relationship to the Hudson River.

The lower portion of the watershed (Fig. 1) is highly urbanized; modifications include stream channel alterations and degraded water quality (Stevens *et al.* 1994), including effluent from a combined sewer overflow on the north bank under the River Road bridge. Two barriers to upstream movement of fishes were identified by Schmidt and Cooper (1995), a partial barrier located about 0.7 km upstream of the mouth of Quassaic Creek and an eroding dam about 1.1 km upstream of the mouth. This study concentrated on that portion of Quassaic Creek downstream of the dam (Figs. 1 and 2). Sampling was done at five stations within this area, which included several different habitats: a plunge pool under the dam, rocky riffles, deep pools, tidal areas, and gravel and sand substrate. Average water depth throughout the sample area was <2.4 m. Sampling stations defined for this study area were (Figs. 1 and 2):

Station 1. Southeast channel at confluence with Hudson.

Station 2. Northeast channel at confluence with Hudson.

Station 3. Quassaic main channel (above Stations 1, 2) to River Road.

Station 4. Quassaic main channel (above Station 3) to first impassable dam.

Station 5. At first impassable dam.

Procedures—Of particular interest to this study was the presence and behavior of anadromous and potamodromous species. Anadromous fishes enter freshwater rivers to spawn, spend up to several years growing in freshwater, and then migrate downstream to the ocean where they mature, which may also take several

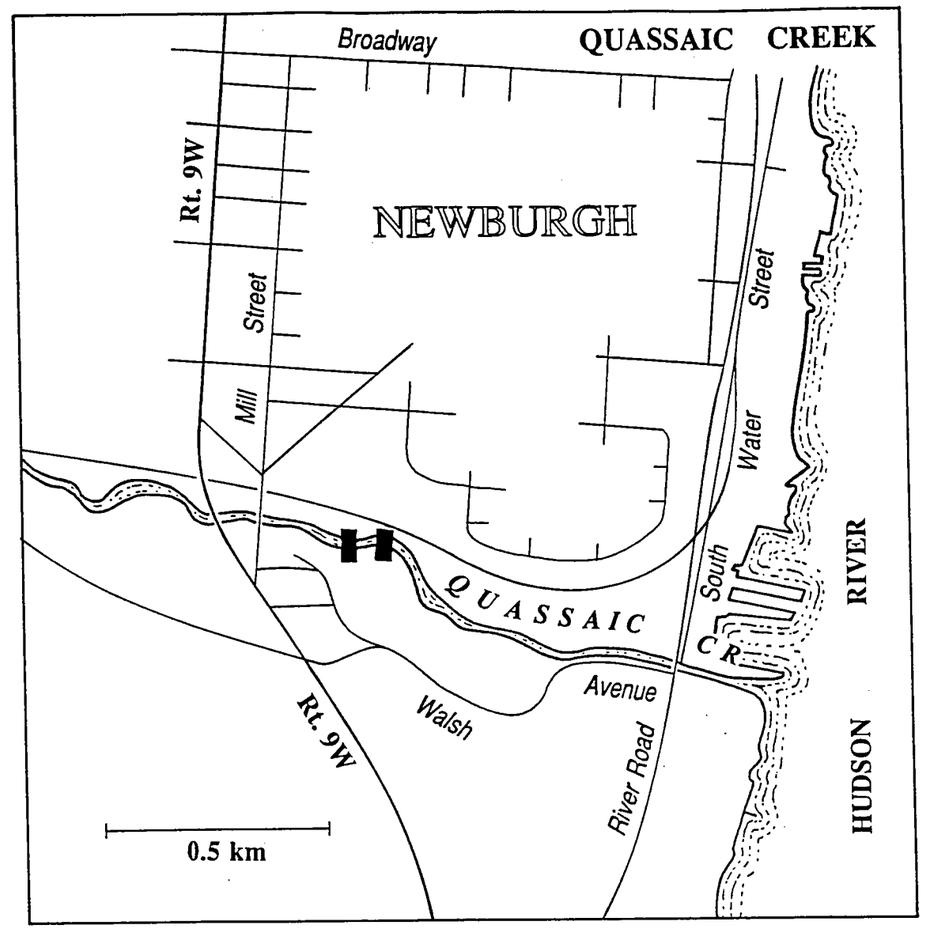

Figure 1. Mouth of Quassaic Creek, Newburgh, New York (from Schmidt and Cooper 1995). The two black bars are barriers to upstream movement of fishes. Station 5 is located at the base of the second barrier.

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years. Potamodromous fishes are those that migrate from a large body of freshwater (e.g., the tidal freshwater Hudson) into tributary streams for spawning (Schmidt 1996). Methods of sampling were designed to quantify *immigration* (potentially anadromous and potamodromous fish entering Quassaic), *emigration*

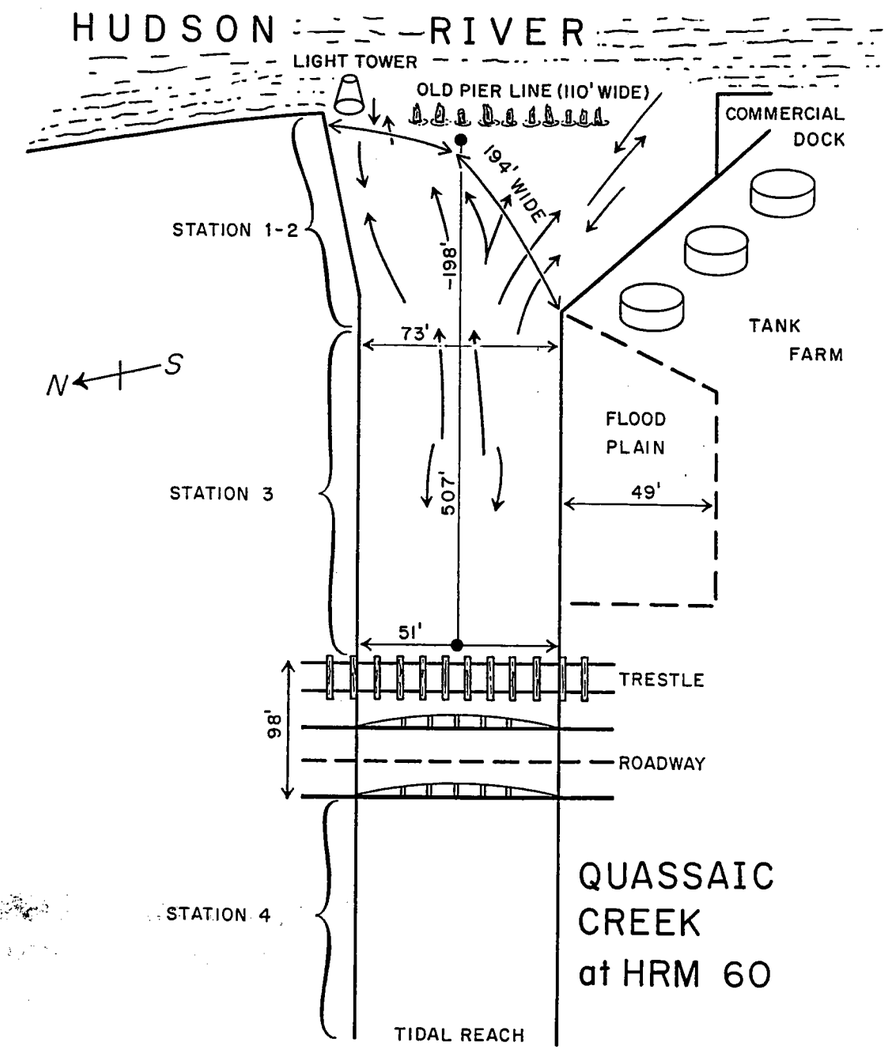

Figure 2. Diagram of the mouth of Quassaic Creek showing locations of sampling stations 1-4 (Station 5 is shown on Fig. 1).

(fish leaving Quassaic), as well as resident species and young-of-the-year documentation.

Sampling was divided into spring and summer periods. The spring sampling period focused on spawning adults. For this reason, the major sampling gear was monofilament gill nets of four different sizes (15.5 m X 1.8 m X 6.4 cm stretch mesh; 15.5 m X 1.8 m X 3.2 cm stretch mesh; 15.5 m X 1.8 m X 2.5 cm stretch mesh; and 36.5 m X 1.8 m X 2.5-7.6 cm stretch mesh). A *Standard Set* (Fig. 3) was used at Stations 1 and 2 consisting of three 15.5 m gill nets of two stretch mesh sizes (6.4 and 3.2 cm) set next to each other radiating from the shoreline approximately 3-5 m apart (Fig. 3). Smaller fish (e.g., spottail shiner) were able to pass through the outer nets but were captured by the inside net (which was designed to catch rainbow smelt, *Osmerus mordax*). Standard sets were made approximately every 1¼ days, generally during a late-afternoon or early evening ebb. The nets were checked periodically during the night, and then removed the following morning on the next ebb tide. These sets took advantage of night flood tides to measure immigration into Quassaic. Each fish captured was identified, measured (total length), sexed if possible, and then released if possible. From late March through early June, standard sampling protocol was difficult at stations 2—5 due to water level and velocity (high flow hampered the setting and efficiency of sampling gear).

The magnitude of spawning runs of alewives and several potamodromous species was estimated from their numbers collected in gill nets. We assumed that the gill nets (Fig. 3) collected all the individuals entering Quassaic from the south and, since our nets covered half the creek, we assumed that we intercepted half of the individuals immigrating on any given night. We estimated the relative magnitude of immigration during daytime flood tides by dividing average catch per gill net (CPUE) during the day by average CPUE at night and multiplying that percentage by our estimated nighttime run. We assumed that runs were similar in magnitude on subsequent nights that we did not sample. These calculations gave us what we think is a minimum estimate of the total run.

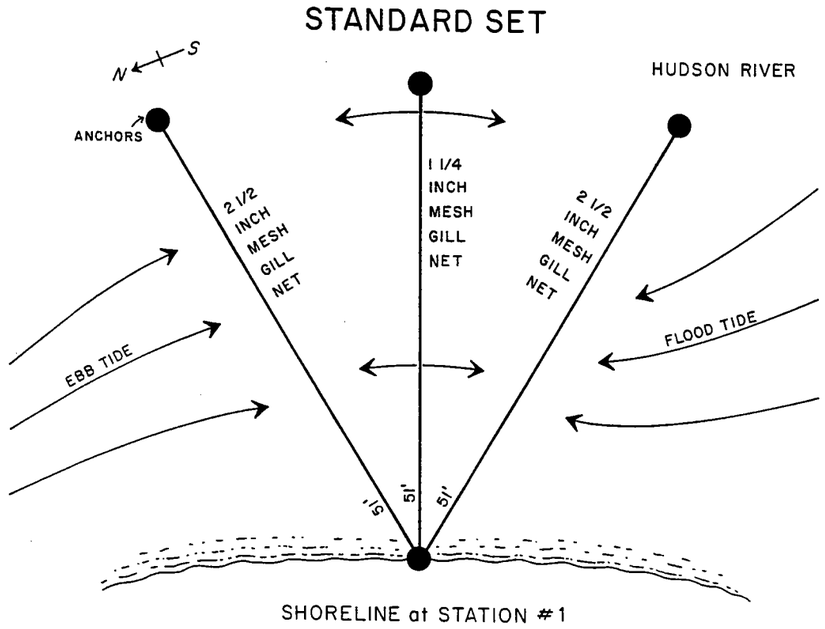

Figure 3. Diagram of a "standard set" of gill nets at the mouth of Quassaic Creek. This arrangement was designed to distinguish between immigrating and emigrating individuals of different sizes.

The summer sampling period focused on young-of-the-year and juvenile fishes, and for this reason the major sampling gear was seines (16.8 m X 1.8 m X 0.64 cm mesh; 9.1 m X 1.5 m X 0.32 cm mesh; 4.6 m X 1.5 m X 0.32 cm mesh; 1.8 m X 0.9 m X 0.5 cm mesh; and 25.9 m X 1.2 m X 0.64 cm mesh). Seine sampling was more qualitative than gill net sampling aimed at documenting the presence and relative abundance of fishes. Seine sampling was conducted every 3.4 days. Summer sampling was less frequent than spring sampling (3.4 vs 1.2 days) due, in part, to the less dynamic aspects of the site following the spawning season.

Results

During this study we collected 4451 fish representing 30 species, 20 genera, and 11 families (Appendix Table 1). The historical origin of these 30 species in the Hudson River watershed (Table 1) reflects the complex geologic and sociological history of the Hudson with native species coming from several glacial refugia and with several life history strategies.

All the species listed by Anderson (1988) as defining a Hudson River tributary mouth community were collected in our study (Table 2). However, the significance of Quassaic Creek to the Hudson River may lie with those species that are present for only a small part of the study (either as spawning adults or *yoy*) like alewives, white perch, striped bass, or white suckers.

The following is a summary of the state of our knowledge of the Hudson River populations of the species we collected in this study.

<u>Anquillidae - freshwater eels</u>

American eels *(Anguilla rostrata)* are the only Hudson River example of catadromous fish. They arrive from the sea as unpigmented juveniles (glass eels), spend their lives maturing in fresh and brackish water and then return to saltwater to spawn. During this study American eels were found at Stations 1-4, and 85 were collected, primarily from eel pots at Station 2. Two pigmented elvers (a juvenile life stage) were found (~50 mm) in a rusted soda can on June 6 at Station 1. A dozen elvers (45-60 mm) were collected immigrating into Quassaic between June 21 and July 6 at Stations 2-4. Larger elvers (110-177 mm) were collected between July 7 and August 29, at Station 2. The presence of elvers in Quassaic is not unexpected since many ascend tributaries as juveniles to reach freshwater impoundments above the fall line. The adult eels collected in Quassaic during spring sampling were primarily scavengers of fish eggs and consumers of fish larvae. Larger American eels are considered residents in tributary mouths (Anderson 1988), sometimes dominating the fish fauna (R.E. Schmidt, pers. obs.).

Table 1. History of origin of fishes collected in Quassaic Creek, Newburgh, New York in 1996. Categories are taken from Smith and Lake (1990).

# of Species	Origin
7	Freshwater—Atlantic Coast Refugium
6	Freshwater—uncertain origin
5	Diadromous
5	Introduced
3	Estuarine
2	Freshwater—Mississippi Refugium, canal immigrant
2	Freshwater—periglacial

Clupeidae - herrings

Blueback herring *(Alosa aestivalis)*, along with the alewife, are often referred to as "river herring". They are anadromous, entering freshwater from the sea in spring as spawning adults. Two blueback herring adults were collected at Station 1, on May 21 (264 mm ♀; water temp. 16°C) and May 30 (279 mm ♂; water temp. 15°C). These were no doubt heading upriver since there was no evidence of blueback herring spawning in Quassaic. *Yoy* blueback herring first appeared at Station 2 on July 1 (24-31 mm), and were found continually in samples throughout the remainder of the study ending September 26 (51-53 mm).

Alewife *(Alosa pseudoharengus)* are the first of the herrings to arrive from the sea each spring, often showing up in late March in the lower estuary. In this study, they were found at Stations 1-4. During spring sampling, 531 adults were collected at Stations 1-2 (52% ♂, 48% ♀). Adult males averaged 266.7 mm; adult females averaged 272.9 mm. They first arrived at Quassaic on April 3. In the typical fashion of anadromous fishes, the first arrivals were all male (Fig. 4). The first females arrived on April 14 (water temp. 8.3°C) with the first increase in their presence (onset of peak spawning) occurring on April 19 (water temp. 9.4°C). Alewives were observed spawning on April 28 (water temp. 13.9°C), and again on May 14 amidst rocky riffles and cobbles (water temp. 13.3°C), at Station

Table 2. Number of fishes collected in Quassaic Creek, Newburgh, New York in 1996. Use categories are our subjective idea of the major reason for the presence of species in Quassaic (A = Anadromous, P = Potamodromous, C = Catadromous, Y = Young-of-year, R = Resident, I = Incidental). Asterisks indicate species listed by Anderson (1988) as tributary mouth community members.

Species	Spring	Summer	Total	Use Category
Alosa pseudoharengus	531	1077	1608	A
Alosa sapidissima	2	508	510	Y
Alosa aestivalis	2	501	503	Y
Morone saxatilis	14	476	490	Y
**Notropis hudsonius*	242	110	352	P
Morone americana	189	106	295	P
Etheostoma olmstedi	0	217	217	R
Lepomis auritus	1	106	107	R
Anguilla rostrata	70	15	85	C
**Fundulus diaphanus diaphanus*	1	49	50	R
Catostomus commersoni	46	1	47	P
**Notemigonus crysoleucas*	43	0	43	R
Semotilus corporalis	1	29	30	R
Ameiurus catus	23	0	23	I
**Lepomis macrochirus*	16	2	18	R
Cyprinus carpio	14	2	16	P?
**Lepomis gibbosus*	10	5	15	R
Perca flavescens	9	1	10	P
Ameiurus nebulosus	7	0	7	I
Micropterus salmoides	3	4	7	I
Pomoxis nigromaculatus	5	0	5	I
Esox niger	1	2	3	I
Micropterus dolomieu	1	1	2	I
Trinectes maculatus	0	2	2	I
Carassius auratus	1	0	1	I
Ameiurus natalis	1	0	1	I
Ictalurus punctatus	1	0	1	I
Esox americanus americanus	0	1	1	R
Salvelinus fontinalis	1	0	1	I
Fundulus heteroclitus	0	1	1	I

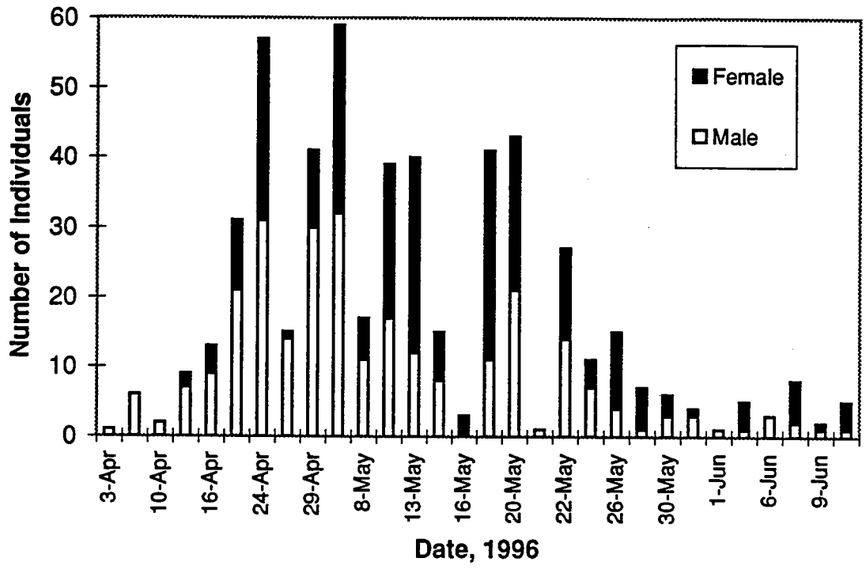

Figure 4. Number of adult alewives immigrating into Quassaic Creek, Newburgh, New York in 1996.

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4. Females were releasing their eggs (a beautiful golden amber) in 30-43 cm of water. Three spent (spawned-out) females were found on May 16 at Station 3, followed by nine more the next day at Station 1. Four spent males were found at Station 1 on May 21. Through June 7, females were found to be immigrating and emigrating, with spawning roe on the way in, and a spent condition on the way out. On June 9, for the first time since April 14, no females were found to be immigrating into Quassaic. On June 13 (water temp. 22.8°C) there were no alewives found at all for the first time since April 3. This was repeated the following day, and thereafter no adult alewives were found at Quassaic. The spawning population for spring 1996 was estimated at ~5600 individuals, many more than we predicted from data on drift of eggs and larvae (Schmidt *et al.*, 1994). Limburg and Schmidt (1990) documented river herring spawning in Quassaic Creek but could not identify their eggs and small larvae to species. Like

other tributaries nearby, the river herring spawning run in Quassaic Creek is composed virtually entirely of alewives.

Four yearling alewives (one-year-olds) were collected at Station 1, on April 24 (119 mm), May 26 (158, 162 mm), and June 6 (156 mm). This suggests that alewives in the Hudson may be represented by several divergent life history strategies, ranging from a resident population, to typical anadromy, to an over-winter stage for *yoy* (K. Limburg, pers. comm.). The first *yoy* alewives (~30 mm) appeared at Stations 2 and 4 on June 28. By July 6, they were dominating the catch (21-38 mm). Yearling striped bass were observed on July 24-25 preying on *yoy* alewives. Several (~165 mm) striped bass had *yoy* alewives (~35 mm) protruding, tail first, from their mouths. Alewives were continually found in samples (~53 mm) through September 1.

American shad *(Alosa sapidissima)* are, like the river herrings, anadromous. However, no adults were encountered during this study which confirms that Quassaic does not provide spawning habitat for American shad. Two yearling shad were collected at Station 1, on May 20 (112 mm) and May 29 (113 mm). As with yearling alewives, this supports the theory that American shad in the Hudson may be represented by several divergent life history strategies, ranging from typical anadromy to an over-winter stage for *yoy* (K. Limburg, pers. comm.). *Yoy* American shad first appeared at Station 2 on June 28 (30-33 mm), and were continually found in samples throughout the remainder of the study, dominating the catch from September 21-26 (71-79 mm).

<u>Cyprinidae - carps & minnows</u>

Goldfish (*Carassius auratus*) are a 19th century introduction to the Hudson River and were common in tidal fresh water until the late 1970s when a furunculosis epidemic drastically reduced their population. In this study, goldfish were represented by a single specimen (151 mm) collected May 8 at Station 1. The status of goldfish in Quassaic Creek could not be established. They could be

potomodromous or, like the closely related common carp, spawn along the periphery at the mouth of Quassaic.

Common carp (*Cyprinus carpio*) are our largest cyprinid (minnows) often weighing 9-12 kg or more. They were introduced into the Hudson from Eurasia in 1832 and are now common in the river. During this study, carp were found at Stations 1-4. They were first seen on April 1 (759 mm ♂) at Station 1. The only spawning activity witnessed was at the periphery of Station 2 on May 20, 21, and 22, a period of wildly fluctuating water temperatures (20.5°, 16°, and 17°C, respectively). On July 2 at Station 4, several adult carp (~560-610 mm) were observed rummaging around active redbreast sunfish nests. We concluded that they were consuming eggs. During this study, 16 carp were collected (4 ♂, 6 ♀, 4 juveniles, 2 unknown sex) at Stations 1 and 3. Gravid females were collected at Station 1 on April 29 (559 mm, water temp. 12.2°C), June 4 (584 mm, 17.7°C), and June 14 (635 mm, 21°), and at Station 3 on May 17 (604 mm, water 13.3°). These individuals may be potamodromous (Schmidt and Stillman 1994), but are only a small fraction of a very large population.

Golden shiner (*Notemigonus crysoleucas*) are another rather large cyprinid, reaching 28 cm in length. Adults in breeding colors are a brassy gold with bright reddish-orange pectoral, pelvic and anal fins. They were first seen at Quassaic on April 3. There was evidence of spawning at Station 1, including a spent female found emigrating on June 6 (228 mm, 17.2°C) and a gravid female found immigrating on June 10 (195 mm, 21°C). During this study 43 golden shiners were collected (20 ♂, 14 ♀, 9 unsexed). The males averaged 201.2 mm; the females averaged 205.1 mm. Although some golden shiners are likely to be potamodromous, since few gravid females were collected during spring sampling and no *yoy* were found during summer sampling, the relative contribution of Quassaic to their Hudson River population would appear to be minimal.

Spottail shiner (*Notropis hudsonius*) are truly a Hudson River minnow, having been described by Governor DeWitt Clinton in 1824 and named for its type locality, the Hudson River. During this study, spottail shiners were found at Stations 1-4. They were first collected on April 10 (water temp. 8.9°C). They were unique among the fish fauna found at Quassaic in that they were not inclined solely toward nocturnal movements. As many, or more, spottails were collected during daylight as in overnight sets. Males dominated until April 19, when females began to dominate the spawning run (water temp. 9.4°C, Fig. 5). Female domination continued, reaching a peak on May 16 (water temp. 13.3°C) and culminating on June 10 (water temp. 22.2°C). The spawning run, as measured by catch of gravid females, began to decline by May 23. From May 10 onward, spottails were found immigrating and emigrating—gravid females on their way in, spent females on their way out. During spring sampling, 242 adult spottail shiners were collected between April 10 and June 9 (113 ♂, 129 ♀) and our estimate for the total spawning run was approximately 2850 individuals. The adult males averaged 113.0 mm and the adult females averaged 111.8 mm. Adults were also found during summer sampling, although their abundance declined. *Yoy* first appeared (~25 mm) on June 28 at Stations 2 and 3. Their presence peaked on July 1 (15-20 mm) at Station 2, and declined thereafter. The evidence clearly indicates that spottail shiners are potamodromous and were using Quassaic as spawning habitat.

Fallfish (*Semotilus corporalis*) are the largest native cyprinid in the Hudson, reaching 43 cm in length. During this study they were found at Stations 1-4, though represented only by a single adult collected on April 10 (256 mm ♂) at Station 1. The first *yoy* were found on June 28 (~31 mm) at Station 4. They continued to be collected from Stations 2-4 through August 6, when they were last found (~44 mm) at Station 4. Despite the fact that no gravid females were collected during this study, the presence of many *yoy* at Station 2-4 indicated that

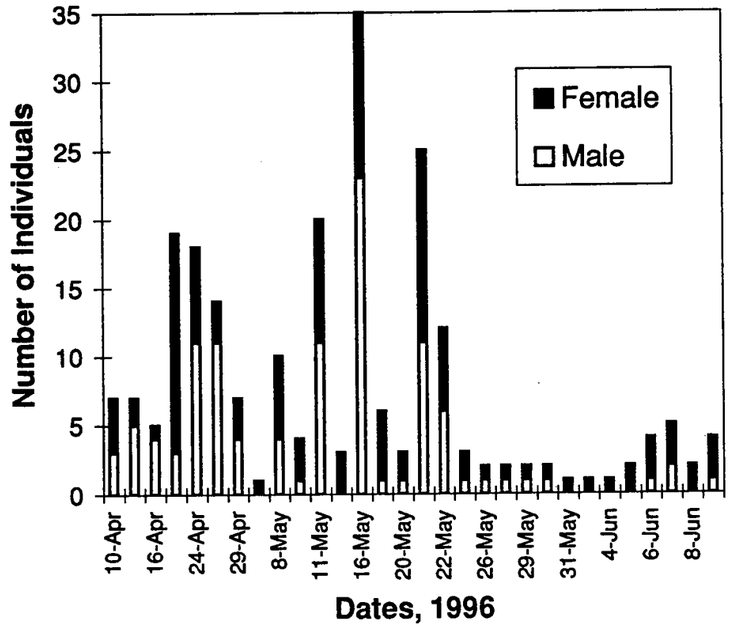

Figure 5. Number of adult spottail shiners immigrating into Quassaic Creek, Newburgh, New York in 1996.

spawning had occurred. This leads to the conclusion that either fallfish are a resident species, or we missed the adults during immigration.

Catostomidae - suckers

White suckers *(Catostomus commersoni)* are recognized as a "river fish," which uses tributaries for spawning, i.e., potamodromy. During this study white suckers were found at Stations 1-5. During spring sampling, 46 adults were collected (30 ♂, 16 ♀). Males averaged 311.9 mm; females averaged 352.2 mm. They were first seen on March 31, with the first 18 being males (Fig. 6). The first female was collected on May 2 (451 mm, water temp. 12.2°C) at Station 1. Five adult males with breeding tubercles were collected: May 3 (301 mm, water temp.

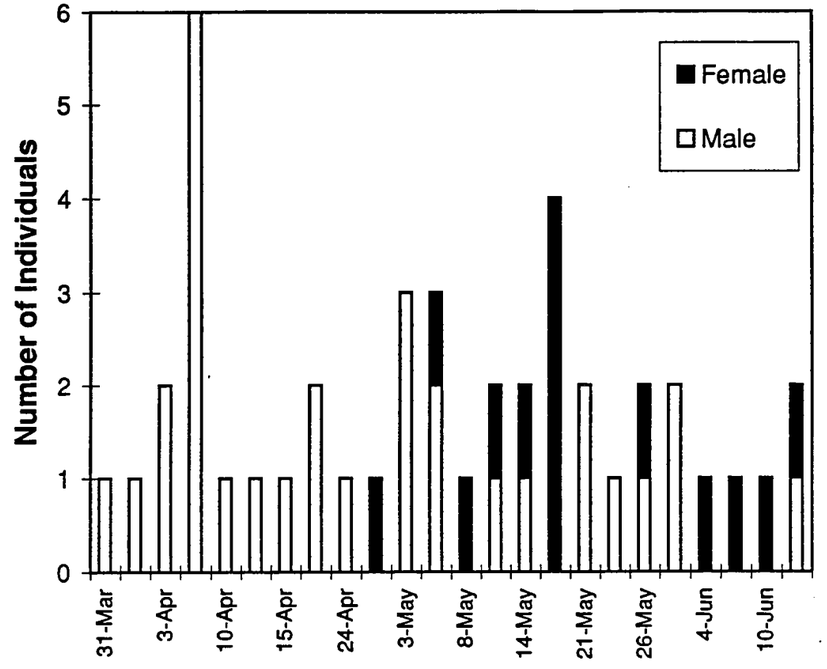

Figure 6. Number of adult white suckers immigrating into Quassaic Creek, Newburgh, New York in 1996.

13.3°C) at Station 1; May 6 (308 and 321 mm, water temp. 13.9°C) at Station 5; and June 14 (489 mm, water temp. 21°C) at Station 1. Three spent females were collected emigrating Quassaic at Station 1: May 26 (362 mm, water temp. 15.6°C); June 4 (381 mm, water temp. 16°C); and June 10 (315 mm, water temp. 21°C). No *yoy* were found during summer sampling. This lead to the conclusion that either they eluded sampling efforts or left Quassaic for the river prior to the start of the summer sampling. Despite the lack of *yoy*, the evidence clearly indicates that white suckers are potamodromous and were using Quassaic as spawning habitat. We estimated that this spawning run contained about 420 adult

white suckers. Schmidt and Stillman (1994), citing the scarcity of larvae in the tidal Hudson, have suggested that tributaries provide the majority of spawning habitat for this species.

Ictaluridae - bullhead catfishes

White catfish (*Ameiurus catus*) are the common estuarine catfish in the Hudson, ranging throughout the entire length and breadth of tidewater. During this study white catfish were found only at Station 1. During spring sampling 23 were collected (11 ♂, 12 ♀). They were first seen at Quassaic (435 mm ♂) on April 24. Some gravid females (248-413 mm) were collected emigrating between April 29 (water temp. 12.2°) and June 14 (water temp. 22.2°C), but no *yoy* were found during summer sampling. Since relatively few gravid females were collected during spring sampling and no *yoy* were found during summer sampling, the relative contribution of Quassaic to their Hudson River population is unknown.

Yellow bullhead (*Ameiurus natalis*) are typically freshwater catfish and were previously reported from Quassaic (Schmidt 1987). During this study they were represented by a single specimen (255 mm ♂) taken May 30 at Station 1. No *yoy* were found during summer sampling. While yellow bullheads may be associated with Quassaic, there was little evidence to support any hypotheses concerning the nature of that association.

Brown bullhead (*Ameiurus nebulosus*) are the common freshwater catfish in the Hudson River. During this study, they were found at Stations 1-2. They were first seen at Quassaic on May 11 (3 ♀, 255-262 mm, water 14.4°C) at Station 1. During this study seven adult brown bullheads were collected (3 ♂, 4 ♀). No *yoy* were found during summer sampling. While brown bullheads most likely are associated with Quassaic (i.e., the four females were gravid) there was insufficient evidence to support an hypothesis concerning the nature of that association.

Channel catfish (*Ictalurus punctatus*) are not native to the Hudson River watershed. They are believed to be a canal introduction from either Lake Champlain, or the Mississippi refugium via the Great Lakes (Smith 1985). During this study, they were represented by a single specimen (267 mm ♂) collected May 30 at Station 2. No *yoy* were found during summer sampling. It is unclear if channel catfish are in any way associated with Quassaic Creek other than an incidental presence.

Esocidae - pikes

Redfin pickerel (*Esox americanus americanus*) are small, nongame esocids (pike) that frequent shallow, sluggish, weedy areas. They are found in nearby Moodna and Woodbury creeks (river mile 58) and were previously reported from the non-tidal Quassaic (Schmidt 1985). During this study, they were represented by a single *yoy* (59 mm) collected June 28 at Station 4. It is concluded that spawning had occurred in Quassaic but there is no evidence to support their relationship to the Hudson River.

Chain pickerel (*Esox niger*) are rather common in the shallow, weedy freshwater areas of the Hudson River, particularly in tributaries. During this study they were found at Stations 1-3. An adult specimen (534 mm ♂) was collected on May 8 at Station 1. Another adult (~300 mm) was observed June 28 at Station 3. One *yoy* (76 mm) was collected on July 25 at Station 3. While we believe that chain pickerel are potamodromous, considering the almost total lack of aquatic vegetation and the few adults and even fewer *yoy* collected during this study, we concluded that their dependence upon Quassaic for spawning habitat is minimal.

Salmonidae - trouts

Brook trout (*Salvelinus fontinalis*) are the official New York State fish.

They are native to the upland streams of the Hudson watershed and are probably of periglacial origin. They are a salmonid of clear, cool, well aerated waters, and are not normally associated with the warm, turbid tidewater of the Hudson estuary. A single specimen (305 mm ♂) was collected June 7 at Station 1. This occurrence appears to be anomalous—brook trout are fall spawners—and may have originated as a stocked fish. There was no evidence that any salmonids use Quassaic for any purpose other than an incidental presence. The nearest likely source for this brook trout, was Moodna Creek at river mile 58, or Fishkill Creek, directly across the Hudson at river mile 60.

Fundulidae - killifishes

Eastern banded killifish (*Fundulus diaphanus diaphanus*) are the common killifish of Hudson River fresh and brackish water. The brilliantly iridescent blue bars of adult males in breeding colors can be so spectacular that they are colloquially called "blue-banded mudminnows". Their long, broad, flat heads have lead to another colloquial name, "hardheads." During this study banded killifish were found at Stations 1-3. Only one adult specimen (109 mm ♂) was collected during spring sampling on May 10 at Station 1. Many adults and *yoy* were collected during summer sampling. Males in breeding colors, as well as females, were found regularly between August 6 and September 26. Males ranged in size from 50-115 mm; females were 50-97 mm. From the evidence, it is unclear if banded killifish were using Quassaic for spawning habitat. The paucity of aquatic vegetation, usually associated with killifish habitat, makes us doubt that they were spawning here, but they are residents.

Mummichog (*Fundulus heteroclitus*), a killifish, are usually associated with brackish water in the Hudson River. During this study, they were represented by a single male, in breeding colors (93 mm), collected July 25 at Station 2. Mummichogs may be more common at Quassaic during years of limited precipitation and higher salinity.

Moronidae - river basses

White perch (*Morone americana*), like white catfish, are ubiquitous in Hudson tidewater. They are equally at home in the fresh water of Quassaic Creek as they are in the brackish waters of New York Harbor. During this study, they were found at Stations 1-4. During spring sampling, 189 white perch were collected (55 ♂, 108 ♀, 26 unsexed). Of these, 66% were gravid females, and most found immigrating into Quassaic. They were first seen on March 31. By April 14 (water temp. 8.3°C) females began to dominate the catch (Fig. 7). Adult males averaged 185.3 mm; adult females averaged 184.1 mm. *Yoy* were collected regularly between June 28 and September 21 at Stations 2-4. Their mean size generally increased throughout the summer sampling: June 28, 15 mm; July 1, 18 mm; July 2, 17-21 mm; July 7, 24-28 mm; July 8, 25-30 mm; July 24, 37-44 mm; July 25, 36-46 mm; August 6, 50-55 mm; August 29, 60 mm; August 30, 38-51 mm; September 6, 45 mm; and September 21, 48 mm. White perch are known to spawn in tidal tributaries (Waldman 1981), and given the number of gravid females immigrating and spent females emigrating during spring sampling, and the presence of *yoy* at Station 4, we believe that white perch were using Quassaic as spawning habitat. Schmidt and Limburg (1989) collected eggs and larvae in Quassaic and they were second in abundance to alewives. We estimated that the spawning run of white perch in Quassaic Creek was about 1500 individuals.

Striped bass (*Morone saxatilis*), many would argue, are the premier gamefish in the Hudson River, or the Atlantic Coast for that matter. They live much of their life in marine waters but return to fresh water in spring to spawn. Their spawning run includes many 18-23 kg fish, which are pursued by anglers. The Hudson estuary serves as a nursery area for *yoy*, and in one way or another supports most of their succeeding life stages. During this study, striped bass were found at Stations 1-4. During spring sampling, 14 were collected (10 ♂, 1 ♀, 3 unsexed). They were first seen at Quassaic on April 3 (260, 296 mm ♂) at Station 1. Only two adults were collected (407, 724 mm ♂), on May 3 at Station 1. *Yoy*

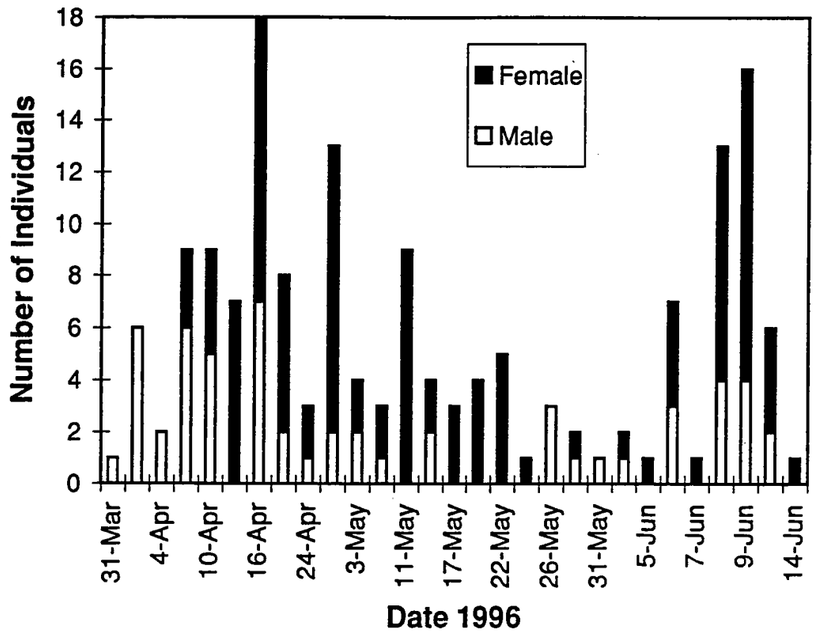

Figure 7. Number of adult white perch immigrating into Quassaic Creek, Newburgh, New York in 1996.

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were first seen on June 28 (20 mm) at Station 2. Their size increased during summer sampling: July 1, 17-21 mm; July 6, 25-31 mm; July 7, 24-28 mm; July 8, 30-32 mm; July 24, 38 mm; July 25, 43 mm; August 6, 63-76 mm; August 7, 80 mm; and August 29, 88 mm. They were continually found in samples throughout the remainder of the study ending September 26. On July 24-25, while lying on the bottom in 1 m of water with a snorkel and mask, TRL watched clouds of *yoy* herring fill the water column moving in large schools as a single unit. Then in an instant they would be gone and in their wake, cruising in three and fours, would come 180 mm yearling striped bass. Several striped bass collected during this time (~165 mm) had *yoy* alewives (~35 mm) protruding, tail first, from their mouths. Others had distended abdomens clearly indicating the results of their

foraging activities. Quassaic Creek does not represent spawning habitat for striped bass. From the evidence, their presence at Quassaic was limited to foraging opportunities as well as a part of their *yoy* nursery-network.

Centrarchidae - sunfishes

Redbreast sunfish (*Lepomis auritus*) are a common species in the Hudson River and many of its tributaries. They are found throughout fresh and minimally brackish water. During this study, redbreast sunfish were found at Stations 1, 3, and 4. They were the first species collected during this study—a single adult on March 24 (108 mm) at Station 1. No further adults were seen during spring sampling. On June 28, at least six adults were observed at the periphery of five active spawning nests at Station 4 (water temp. 21.7°C). Three of these nests were guarded by adult males in breeding colors. These were the same redbreast nests visited by marauding carp on July 1. Hundreds of larval redbreast sunfish (~5 mm) were visually observed, collected and identified, in the vicinity of several nests throughout Station 4 on July 1. While it is obvious that significant spawning occurs in Quassaic, there is no evidence to support a relationship of redbreast sunfish to the Hudson River.

Pumpkinseed (*Lepomis gibbosus*) are the ubiquitous sunfish in the Hudson River, found throughout fresh and brackish water. Pumpkinseed (94 mm) were collected at river mile 35 on July 7, 1995 in 7.0 ppt salinity (Lake 1995). During this study, they were found at Stations 2-5, 13 of which were collected (5 ♂, 8 unsexed). They were first seen at Quassaic on April 24 (69 mm) at Station 1. Since no gravid females or *yoy* were found, there is no evidence to support pumpkinseed dependence upon Quassaic for spawning habitat.

Bluegill (*Lepomis macrochirus*), like the pumpkinseed, are a common sunfish in the Hudson River watershed, ranging throughout fresh and brackish water—bluegills (56 mm) were collected at river mile 35 on September 19, 1995,

in 11.1 ppt salinity (Lake 1995). During this study they were found at Stations 1-5, and 18 of which were collected (11 ♂, 3 ♀, 4 unsexed). They were first seen at Quassaic on April 28 (175 mm ♂) at Station 1. Two gravid females were found immigrating on June 4 (127,165 mm) at Station 1 (water temp. 16°C). Males in brilliant breeding colors were found immigrating on June 12 (153 mm) and on June 14 (159,165 mm) at Station 1. *Yoy* were collected on September 21 (45 mm) at Station 2. Although few adults and *yoy* were collected during summer sampling, the presence of gravid females, and males in breeding colors, indicates that bluegills were using Quassaic for spawning habitat.

Smallmouth bass (*Micropterus dolomieu*) are a major freshwater gamefish in New York State. During this study, smallmouth bass were collected at Stations 2 and 4. One adult was collected on June 1 (353 mm ♂) at Station 4. One *yoy* was collected on July 24 (61 mm) at Station 2. Whereas smallmouth bass are believed to be potamodromous (Schmidt and Stillman 1994), in light of the few adults and *yoy* collected during this study, we concluded that their dependence upon Quassaic for spawning habitat is minimal.

Largemouth bass (*Micropterus salmoides*), like smallmouth bass, are a major freshwater gamefish supporting many Hudson River sportfishing tournaments. During this study, largemouth bass were found at Stations 1-4. Three adults were collected at Station 1, on April 10 (318 mm ♂); April 24 (272 mm ♂); and a gravid female (512 mm, water temp. 17.2°C) on May 21. *Yoy* were first collected on June 28 (31 mm) at Station 4. Three more were collected on July 1 (37-39 mm) at Station 2. Considering the few adults and *yoy* collected during this study, we conclude that their dependence upon Quassaic for spawning habitat is minimal.

Black crappie (*Pomoxis nigromaculatus*) are highly esteemed for their culinary qualities. While not rare in the Hudson, they are less common than the other sunfishes found at Quassaic. During this study five black crappie were collected (4 ♂, 1 ♀) at Station 1. They were first seen on April 28 (207 mm ♂). A second male (184 mm) was found on May 26, and two more males were seen on June 3 (181, 216 mm). One gravid female (355 mm, water temp. 16°C) was collected on May 23. No *yoy* were found during summer sampling. This fact, plus the scarcity of gravid females during spring sampling, argues against black crappie using Quassaic for spawning habitat.

<u>Percidae - perches</u>

Tessellated darters (*Etheostoma olmstedi*) are a fish of shallow, sandy, or gravelly substrate, a habitat they find in abundance at Quassaic. This study failed to find tessellated darters during the spring sampling period yet the presence of many *yoy* during summer sampling at Stations 1-5 indicated that significant spawning had occurred in Quassaic. This led to the conclusion that either tessellated darters are a resident species, or we missed the adults during immigration. Adults (~75 mm) and *yoy* (~32 mm) were first seen during summer sampling on June 28 at Stations 2 and 4. On July 7, smaller *yoy* (21-23 mm) were found at Station 2. *Yoy* size increased throughout the summer sampling: July 8, 25 mm; July 24, 37 mm; August 6, 49 mm; August 29, 55 mm. Adults (70-89 mm) and *yoy* were found in samples throughout the remainder of the study ending September 26.

Yellow perch (*Perca flavescens*) were found during this study at Stations 1-4, nine of which were adults (6 ♂ and 3 ♀). They were first collected on March 31 (251 mm ♂) at Station 2. Two gravid females (226, 267 mm) were collected on April 19 at Station 1 (water temp. 9.4°C). Only one *yoy* was found during the summer sampling (47 mm) collected on July 25 at Station 2. Whereas yellow

perch are likely to be potamodromous, in light of the few adults and even fewer *yoy* collected during this study, it is presumed that their dependence upon Quassaic is minimal.

Soleidae - soles

Hogchoker (*Trinectes maculatus*) are found throughout the Hudson's tidewater, but are usually associated with the brackish reach of the river. For this study, two specimens (47, 57 mm) were collected on July 1 at Station 2. They are not presumed to be using Quassaic for any particular purpose.

Discussion

One of the purposes for our study was to define the general role of Hudson River tributaries as it relates to Hudson River fishes. This is the first study that we know of in the the Hudson looking at seasonal changes in fish populations in a tributary mouth. As such, we can say little about geographic variation within the Hudson estuary and we think that there probably are substantial differences in species composition in different areas of the Hudson.

There are several factors that need to be considered in using our data as an example of seasonal changes in fish communities. The water quality in Quassaic Creek is not good (Stevens *et al.* 1994) and we think that this has affected the resident component of the fauna. Note that the most abundant resident species, tessellated darters, which composed 45% of the resident component (Table 2), are well known for tolerating poor water quality (Smith 1985). We would expect a higher species diversity and probably numbers of resident fishes in a relatively unpolluted stream.

During the spring sampling period (March 24—June 14), high tributary flow inhibited setting gill nets except at Station 1. This may have reduced efficiency and affected results of gill netting. Station 1, where 90% of the

sampling was conducted, was relatively unaffected. Conversely, the high tributary flow may have encouraged a strong alewife run and improved water quality.

Summer sampling also was affected by higher than average flow. July precipitation was 29.1 cm, nearly 30% of the yearly total for the first seven months. The net result of the spring and summer precipitation was no detectable salinity (< 1 ppt) and the absence of many brackish water and all saltwater species at Quassaic. In years with normally low summer rainfall, bay anchovy (*Anchoa mitchilli*), bluefish (*Pomatomus saltatrix*), Atlantic silverside (*Menidia menidia*), Atlantic needlefish (*Strongylura marina*), and an arthropod, the bay barnacle (*Balanus improvisus*), have been documented for this site (Lake, 1996). Schmidt (1985, 1987) reported common shiner (*Luxilus cornutus*) and eastern blacknose dace (*Rhinichthys atratulus*) from the study area, and fourspine stickleback (*Apeltes quadracus*) and zebra mussel (*Dreissena polymorpha*) are freshwater species that have been documented for the site (Lake 1996) but were not recorded in this study. These latter four organisms are freshwater species that should not be affected by rainfall patterns in the Quassaic watershed.

We tried to capture rainbow smelt (*Osmerus mordax*) in late March with no success. Smelt were historically plentiful and a regular component of the early spring anadromous fish spawning. In the last couple of decades, however, few have been found ascending tributaries. One hypothesis is that smelt are spawning in the main stem of the Hudson (Rose 1993). This may have some validity since many *yoy* are impinged or entrained at the Roseton (HRM 65.4) and Danskammer Point (HRM 66.5) generating stations each year (Lawler, Matusky & Skelly Engineers 1994).

Quassaic had three periods of strongly fluctuating water temperatures that seemed to affect presence of fish: from May 20 to 21, water temperature dropped from 20.5°C. to 16°C.; from August 29 to September 1, the water temperature dropped from 25°C to 20.5°C.; from September 6 to 26, water temperature dropped from 24.4°C. to 16°C.

Another limiting factor for the presence of certain fish species was the almost total lack of submerged aquatic vegetation (SAV). Very small areas of pondweeds, curly pondweed (*Potamogeton crispus*) and clasping pondweed (*Potamogeton perfoliatus*) were found at Stations 1 and 3. The most significant area of SAV was throughout Station 3 (albeit thinly scattered), primarily water milfoil (*Myriophyllum* sp.). A very small amount of wild celery (*Vallisneria americana*) was found sporadically at Station 1. In late spring a small area of water chestnut (*Trapa natans*) briefly made an appearance at Station 1. It may have been eventually displaced by heavy stream flow.

The fishes that dominate the mouth of Quassaic Creek in the spring are spawning anadromous and potamadromous species. These spring spawning runs are highly significant, in terms of numbers of fishes and biomass, to Quassaic Creek. If our observations of Quassaic hold true for other Hudson River tributaries, this is a major role that tributaries play in the Hudson ecosystem. It may be very important that anadromous and potamodromous fishes have access to tributary mouths.

The late summer and fall community is dominated by *yoy* clupeids, moronids, and other taxa. These are unlikely to be individuals that were spawned in Quassaic Creek. These species seem to be abundant everywhere in the Hudson estuary and may be abundant in Quassaic Creek only because they are abundant everywhere else.

Conclusions

Quassaic Creek is host to several large runs of anadromous and potamodromous fishes that play significant roles in the Hudson estuary. At least 10,000 individuals entered Quassaic Creek over a three month period to spawn. This is probably the most important role that Quassaic Creek is playing in the Hudson River estuary.

The fishes that are resident in Quassaic Creek, eight species in this study, were not abundant and we think the species diversity is lower than we would expect. We suspect that degraded water/habitat quality may be affecting the resident fish component of the system.

The late summer and fall community is dominated by fishes that are abundant everywhere in the Hudson at that time of year. We do not think that Quassaic Creek is attracting these fishes, but rather they are present because of this very abundance in the estuary.

We would like to see more studies like this one. We have provided the first (albeit crude) estimates of magnitude of spawning runs in a Hudson River tributary. We would like to see similar studies done at least in the upper and lower estuary to provide geographic comparisons.

Acknowledgements

We thank and express our sincere appreciation to Kathleen Schmidt for drawing some of the figures, to Christopher and Phyllis Lake for helping with and tolerating sampling in Quassaic Creek (not the nicest place to be), and to C. Lavett Smith and Karin Limburg for the congenial consultations and long term inspiration.

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Appendix Table 1. Fishes collected by station in Quassaic Creek, 1996.

Fish	Station 1	2	3	4	5
American eel, *Anguilla rostrata*	◆	◆	◆	◆	
blueback herring, *Alosa aestivalis*	◆				
alewife, *Alosa pseudoharengus*	◆	◆	◆	◆	
American shad, *Alosa sapidissima*	◆	◆			
goldfish, *Carassius auratus*	◆				
common carp, *Cyprinus carpio*	◆	◆	◆		
golden shiner, *Notemigonus crysoleucas*	◆	◆			
spottail shiner, *Notropis hudsonius*	◆	◆	◆	◆	
fallfish, *Semotilus corporalis*	◆	◆	◆	◆	
white sucker, *Catostomus commersoni*	◆	◆	◆	◆	◆
white catfish, *Ameiurus catus*	◆				
yellow bullhead, *Ameiurus natalis*	◆				
brown bullhead, *Ameiurus nebulosus*	◆	◆			
channel catfish, *Ictalurus punctatus*		◆			
redfin pickerel, *Esox americanus americanus*				◆	
chain pickerel, *Esox niger*	◆	◆	◆		
brook trout, *Salvelinus fontinalis*	◆				
eastern banded killifish, *Fundulus diaphanus diaphanus*	◆	◆	◆		
mummichog, *Fundulus heteroclitus*		◆			
white perch, *Morone americana*	◆	◆	◆	◆	
striped bass, *Morone saxatilis*	◆	◆	◆	◆	
redbreast sunfish, *Lepomis auritus*	◆		◆	◆	
pumpkinseed, *Lepomis gibbosus*		◆	◆	◆	◆
bluegill, *Lepomis macrochirus*	◆	◆	◆	◆	◆
smallmouth bass, *Micropterus dolomieu*		◆		◆	
largemouth bass, *Micropterus salmoides*	◆	◆	◆	◆	
black crappie, *Pomoxis nigromaculatus*	◆				
tessellated darter, *Etheostoma olmstedi*	◆	◆	◆	◆	
yellow perch, *Perca flavescens*	◆	◆	◆	◆	
hogchoker, *Trinectes maculatus*		◆			