# The Relationship Between Fecundity of an Alewife *(Alosa pseudoharengus)* Spawning Population and Egg Productivity in Quassaic Creek, a Hudson River Tributary (HRM 60) in Orange County, New York

A Final Report of the 1997 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. 1998. The relationship between fecundity of an alewife *(Alosa pseudoharengus)* spawning population and egg productivity in Quassaic Creek, a Hudson River tributary (HRM 60) in Orange County, New York. Section II: 26 pp. *In* J.R. Waldman and W.C. Nieder (Eds). Final Reports of the Tibor T. Polgar Fellowship Program, 1997. Hudson River Foundation, NY.

## ABSTRACT

This research grew out of our 1996 Polgar study at Quassaic Creek. That effort investigated the various components of the Quassaic fishery: anadromous, potamodromous, catadromous, and resident species. An unexpected finding of the 1996 study was the strong spawning run of alewives *(Alosa pseudoharengus)*, far exceeding previous estimates of adult alewives for Quassaic Creek.

We isolated the alewife component of the 1996 Quassaic study, repeated the sampling, and compared the two years of data. This comparison allowed us a higher level of confidence that the unexpected number of alewives in 1996 were not anomalous. In order to better understand the significance of the alewife fishery in Quassaic, we investigated the relationship between alewife fecundity (input) and egg and larval productivity (output).

To estimate total eggs being spawned (input), we created a length-fecundity association for all female alewives. Gill nets were used to collect gonads from 52 alewives. They were measured (TL) and their eggs counted. The resulting length-fecundity association (275.1 mm-72,000 eggs) allowed us to estimate average fecundity for all spawning females in Quassaic Creek. Once we estimated the number of females in the spawning run (2248), we could then estimate the total number of eggs being spawned (162 million).

We collected, identified, and counted eggs and larvae being exported from Quassaic Creek (output) using drift nets. The total number of eggs being exported was estimated at 38 million eggs, or 23% of the total spawned, a 77% mortality rate.

The spawning reach of Quassaic Creek is relatively short (<0.9 km). Drift net collections were taken ~0.24 km from the Hudson leaving ~0.7 km of possible alewife spawning reach. This short distance from spawning location to collection location, as well as the shallow and narrow characteristics of Quassaic Creek, may account for the high survival rate. Eggs and larvae that have to travel longer and through broader and deeper reaches to a collection location would seem to be more susceptible to predation and other mortality factors.

The 1997 alewife spawning run was estimated to be 80% (4496) of the 1996 spawning run (5600). The difference is not unreasonable and could be the result of a dry spring (1997) as opposed to one of high flow (1996). Total egg and larval transport from Quassaic in 1997 was estimated to be $3.8 \times 10^7$, an order of magnitude higher than a 1988 estimate of $9.4 \times 10^6$. It is reasonable to assume that the 1996 egg and larval transport was equal or larger.

## TABLE OF CONTENTS

## LIST OF FIGURES AND TABLES





## INTRODUCTION

The term "River Herring" includes two species of anadromous clupeids that are difficult to distinguish- alewife (*Alosa pseudoharengus*) and blueback herring (*A. aestivalis*). River herring management is soon to become a focus item for the Atlantic States Marine Fisheries Commission (ASMFC). New York State will be required to comply with ASMFC guidelines, among which are to have an understanding of various life history parameters such as spawning range and habitat requirements. Other than anecdotal observations, there is little information available on the use of Hudson River tributaries by anadromous herrings. Such information as which species spawns in which tributary is poorly known. Tributary productivity of either species is similarly unknown.

With this in mind, we had two main purposes for this study: Repeat our 1996 sampling of Quassaic Creek to compare the size of the 1997 alewife spawning run to our estimate for 1996, and compare our 1997 estimate of the alewife spawning run to estimates of the magnitude of egg and larval drift.

In 1996 we demonstrated that alewives were, in fact, spawning very successfully in Quassaic Creek. However, what was the magnitude of Quassaic alewife egg and larval transport into the tidal Hudson? What was the relationship between number of spawning adults and production of eggs and larvae? Previous biological assessments of Quassaic Creek (Schmidt 1985, 1987) implied that productivity should be low. To our knowledge, these kinds of data have never been collected from a Hudson River tributary.

## METHODS

Study area—Quassaic Creek is located at approximately river mile (RM) 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 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 two stations within this area, the entrance of the creek (confluence with the Hudson) and the observed spawning reach at and above the range of tide.

This study required the capture and analysis of both spawning adult alewives and subsequent eggs and larvae from those not captured. The methods varied for each of these efforts.

Adults were captured in gill nets at Station 1, located at the southeast channel at Quassaic's confluence with the Hudson (Fig. 1 & 2). Eggs and larvae were captured in drift nets at Station 4, Quassaic's main channel at the head of tide (Fig. 2).



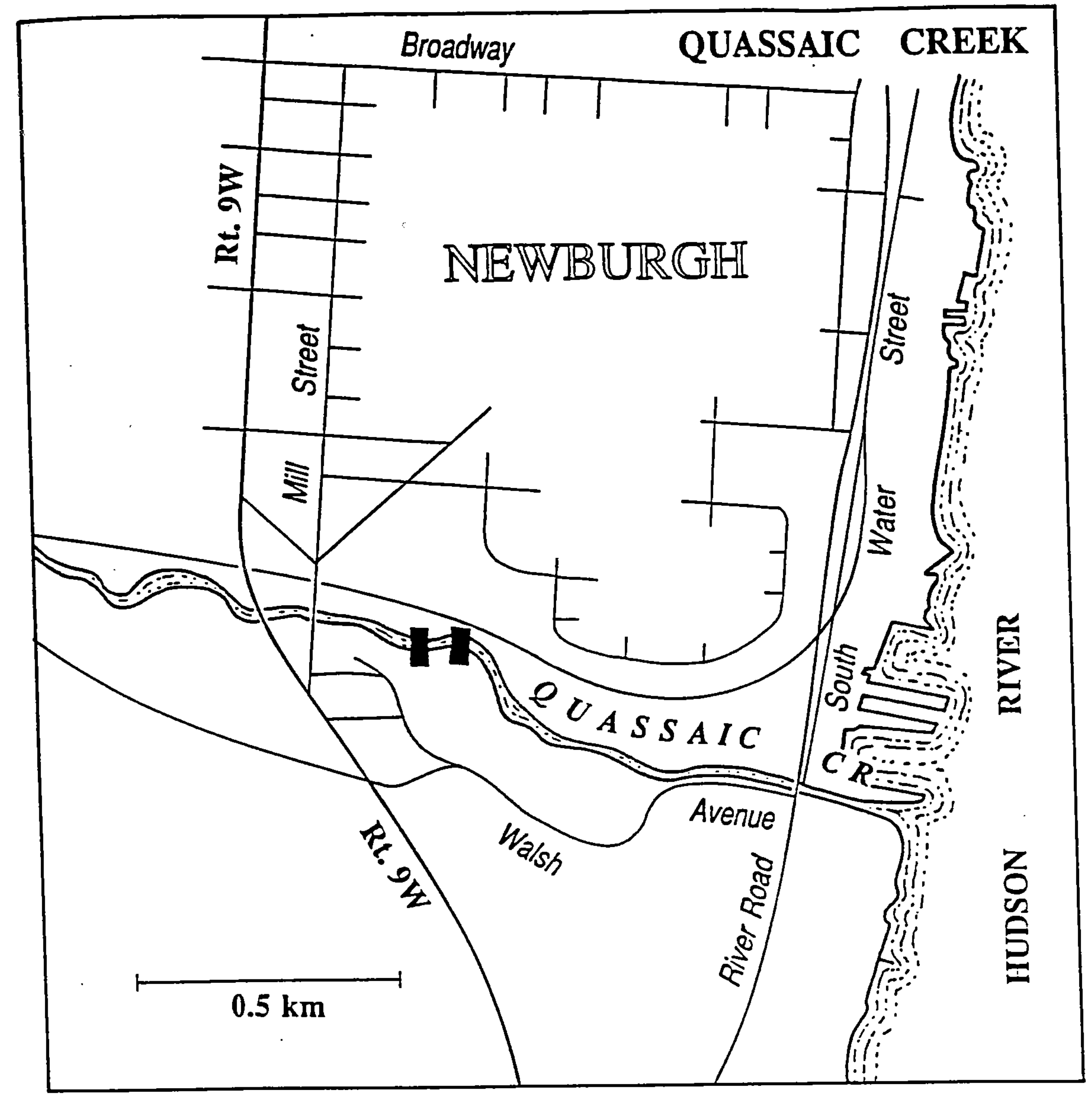


Figure 1. Mouth of Quassaic Creek, Newburgh, New York (from Schmidt and Cooper 1995). The two black bars are barriers to upstream movement of fishes.

Procedures-

Adults: Our study required that we estimate number of eggs being spawned (input) the number of eggs and larvae being exported (output) and, thus, mortality. For this we

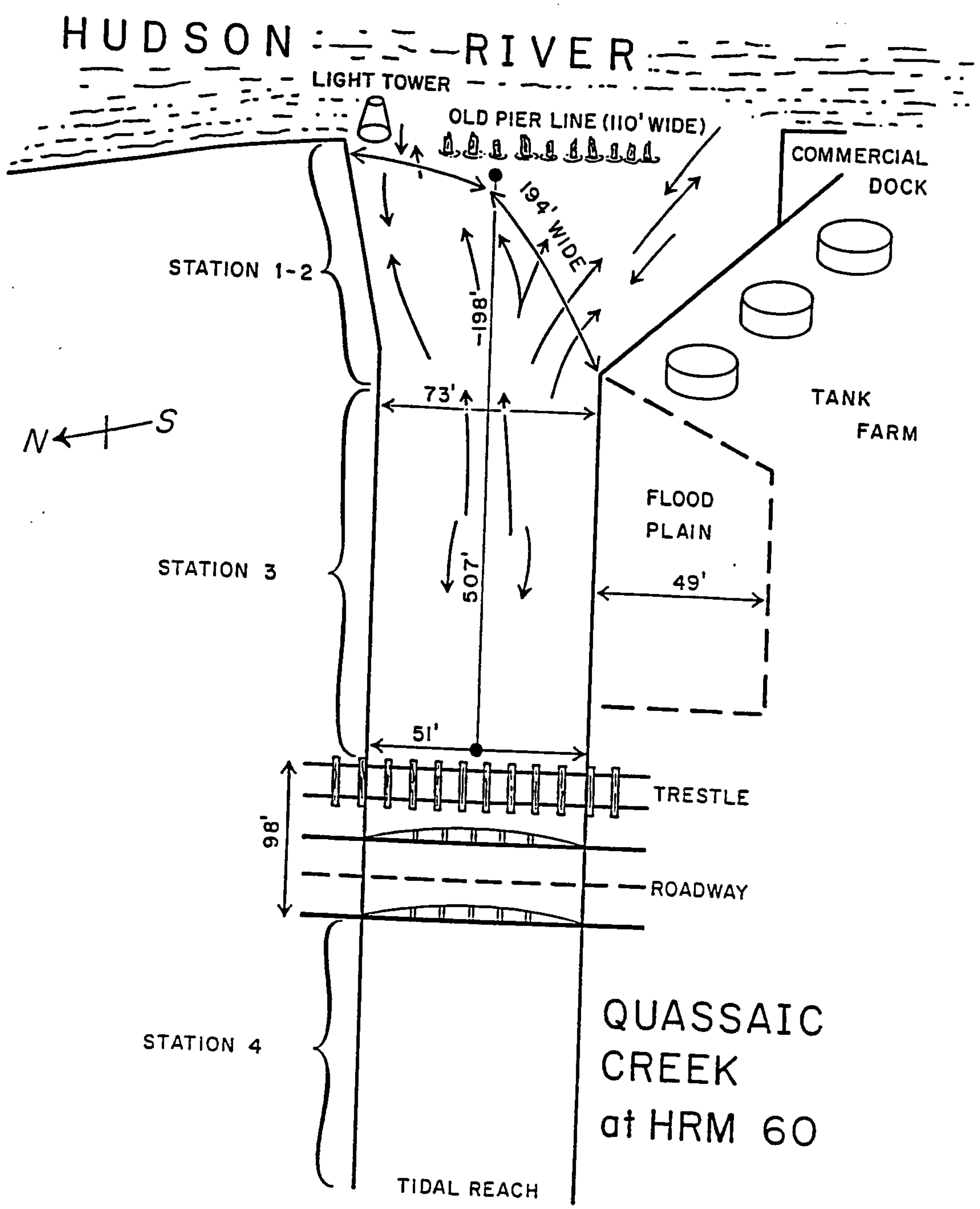


Figure 2. Diagram of the mouth of Quassaic Creek showing sampling locations.



had to capture gravid females with gill nets as they entered Quassaic from the Hudson. This sampling was conducted between March 23 and June 17, 1997.

Monofilament gill nets of two 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) were used in a "standard set" at Station 1 (Fig. 2). This consisted of three 15.5 m gill nets (x 6.4, 3.2, 6.4 cm) set next to each other radiating from the shoreline approximately 3-5 m apart (Fig. 3). The inside net was used to determine direction of fish passage. Standard sets were made approximately every 2 days, generally during a late-afternoon or early evening ebb tide. 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), gender determined if possible, and then released if alive. Alewives did not survive capture and, in addition to the previous data, all were weighed to the nearest gram.

The magnitude of the alewife spawning run was estimated from the numbers collected. 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 (0.71, Lake and Schmidt 1997) and multiplying that percentage by our estimated nighttime run. We

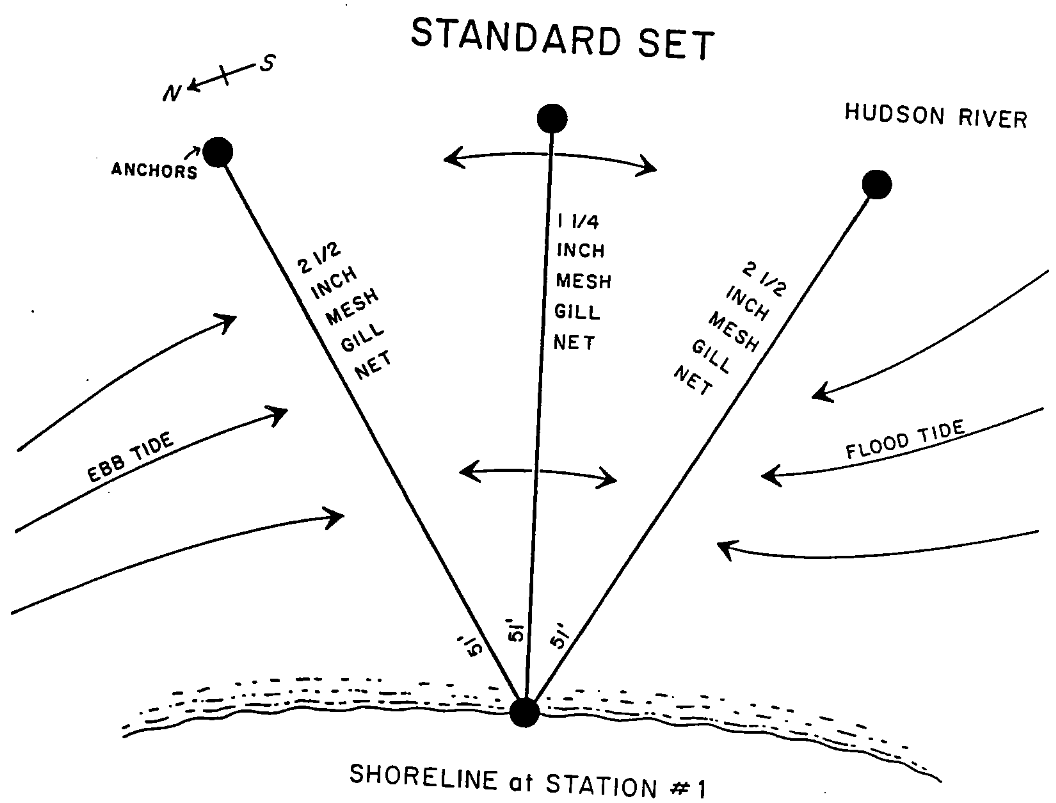


Figure 3. Diagram of a "standard set" of gill nets at the mouth of Quassaic Creek.

---

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.

<u>Fecundity:</u> In the laboratory, ovaries were removed from arbitrarily chosen individuals, within one hour of capture. The ovaries were weighed, labeled, preserved in zip-lock freezer bags in 50% isopropanol, and refrigerated. During subsequent examination, we eliminated those individuals that had spawned or partially spawned. For all the



unspawned fish, we dissected away as much extraneous tissue as possible and then weighed the ovaries. We then removed three small subsamples from ovaries of each fish, weighed them (nearest 0.001 g), and counted eggs in each subsample. There were two sizes of eggs present in the ovaries. We only counted the larger eggs assuming those were the ones that would have been spawned close to the time of capture. The average number of eggs per 0.001 g of ovary was then multiplied by the preserved weight of the entire gonad to derive the estimate of total egg number per fish.

A regression between fecundity and fish length was calculated. The total number of eggs produced by the alewife run was estimated by multiplying the population estimate by the gender ratio (= number of females), calculating the average body length of a female alewife in this run, deriving the fecundity of an average size alewife from the regression, and finally multiplying by the estimated number of females.

<u>Egg and larval drift:</u> We used three standard rectangular drift nets (0.135 $m^2$, opening; 303 μm mesh). The nets were deployed nearshore, midstream, and then midway between those points, facing upstream against the flow. Sampling periods were chosen, as near as possible, to occur during an ebb tide at dusk or after dark. Twenty-hour samples in Stockport Creek (located at RM 121- Schmidt *et al.* 1994) showed that alewife eggs drift at the same rate all day and all night but that yolk sacs drift mostly at dusk.

The drift nets were fished for 20 minutes, removed and the contents collected and preserved in 10% formalin. While the nets were fishing, we measured water temperature (hand held thermometer), velocity of water in each net (Swoffer current meter), and a depth and water velocity transect over the width of the entire creek which was used to estimate stream discharge.

In the laboratory, eggs and larvae were sorted from the samples, identified, and counted. Knowing the total number of eggs and larvae in the samples, we used the flow data (volume through each net), and calculated the number of alewife eggs and larvae per cubic meter. Knowing the flow of Quassaic in cubic meters per second (which we measured), we calculated the number of alewife eggs and larvae coming out of Quassaic per second. We then multiplied the number of alewife eggs and larvae per second by the number of seconds until the next drift net sample—which might be several days. This assumes that drift remains the same until the next sample. So few yolk sac larvae were collected, that we did not distinguish between their drifting behavior and that of the eggs for purposes of calculating magnitude of the drift.

## RESULTS

We collected 415 adult alewives entering Quassaic Creek with precisely half of the individuals being females. This is slightly fewer than the 531 we collected in similar sampling in 1996 (Lake and Schmidt 1997). Males appeared before females and the run had two peak periods, one in late April and one in mid-May (Fig. 4). A similar bimodal pattern was seen in Quassaic in 1996 (Lake and Schmidt 1997) and in Stockport Creek (Schmidt and Stillman 1994). Other potamodromous and incidental species were collected and they have been added to our species list for Quassaic Creek



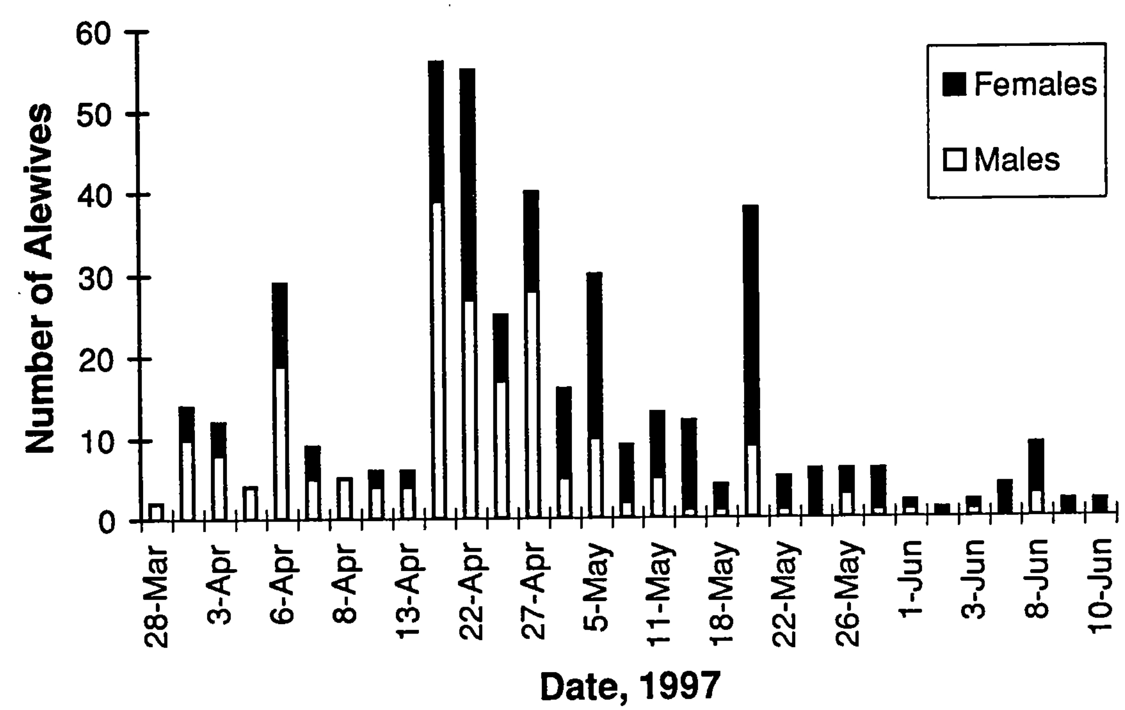


Figure 4. Number of adult alewives immigrating into Quassaic Creek, Newburgh, New York in 1997.

(Appendix Table 1). One major difference between this year and our 1996 collections is the total lack of spottail shiners (*Notropis hudsonius*) in Quassaic Creek this year. We have no explanation for this observation.

From our gillnet sampling, we estimated that there were 4496 total alewives entering Quassaic during the sampling period. This is about 1000 fewer alewives than we estimated in Quassaic in 1996. Of the total number, 2248 were females (~50:50 gender ratio).

The average total length (TL) of all female alewives captured was 275.1 mm. Females ranged from 232-318 mm TL, probably containing several age classes. Males were slightly smaller ranging from 232-302 mm TL.

Ovaries were removed from 55 alewives spanning the run from April 17-June 9, 1997. Three of these alewives were subsequently found to be spent or partially spent, leaving 52 ovaries for analysis. Fresh ovary weight was related to fish weight (correlation coefficient = 0.64) but there was a high variance in the data (Fig. 5). The ovary weight as a fraction of the total fish weight generally declined as the season progressed (Fig. 6) even though average size (TL) of females remained constant.

Fecundity estimates ranged from 15,000-135,000 eggs per female (Fig. 7). The calculated regression of egg number on TL was:

$$\text{Egg \#} = -90{,}098 + 588.1(\text{TL mm})$$

There was a lot of scatter in these data (Fig. 6) and the correlation coefficient for the regression was only 0.45.

Using the average size female alewife (275.1 mm TL), the average fecundity was 71,688 eggs per female. Given that our estimate of the females entering Quassaic Creek was 2248, multiplying gives us an estimate of alewife egg production at $1.6 \times 10^8$ eggs for the season.



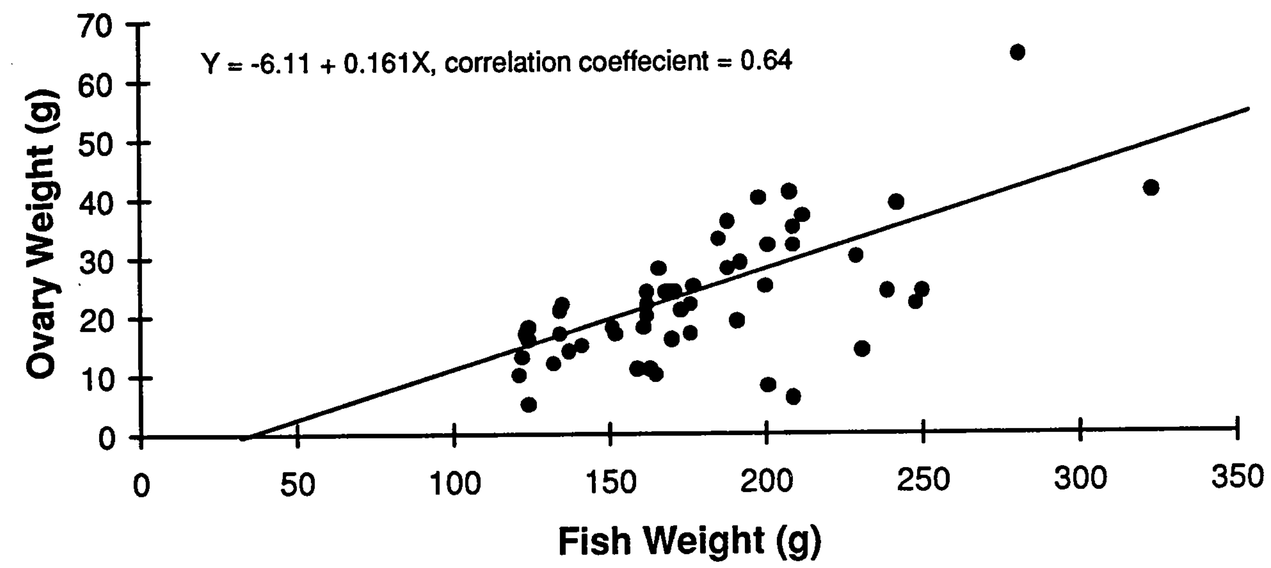


Figure 5. Scatterplot of fresh ovary weight relationship to alewife weight from Quassaic Creek, Newburgh, New York in 1997.

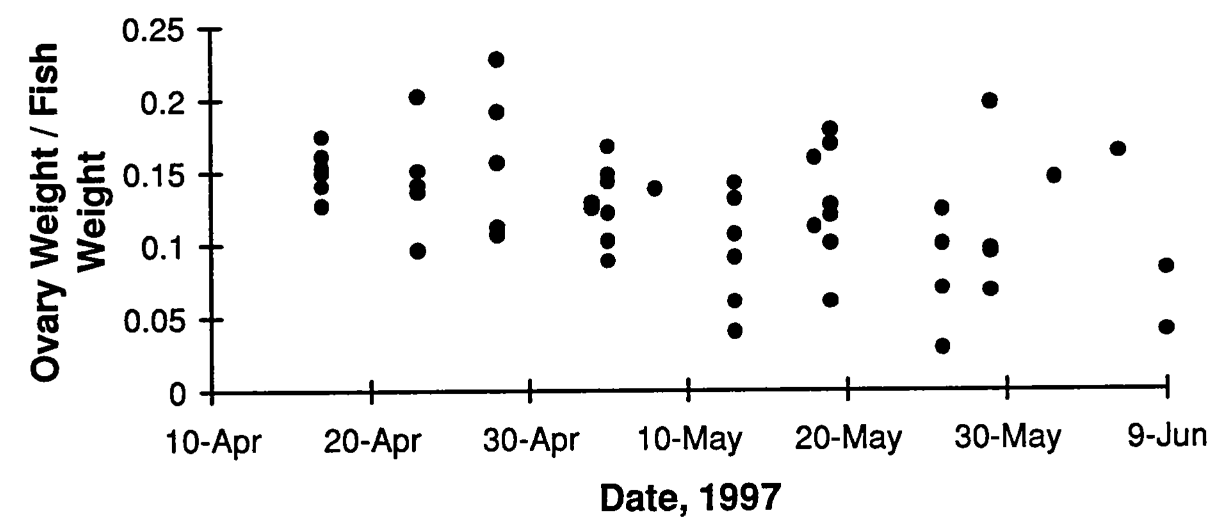


Figure 6. Ovary weight compared to total fish weight in alewives from Quassaic Creek, Newburgh, New York in 1997.

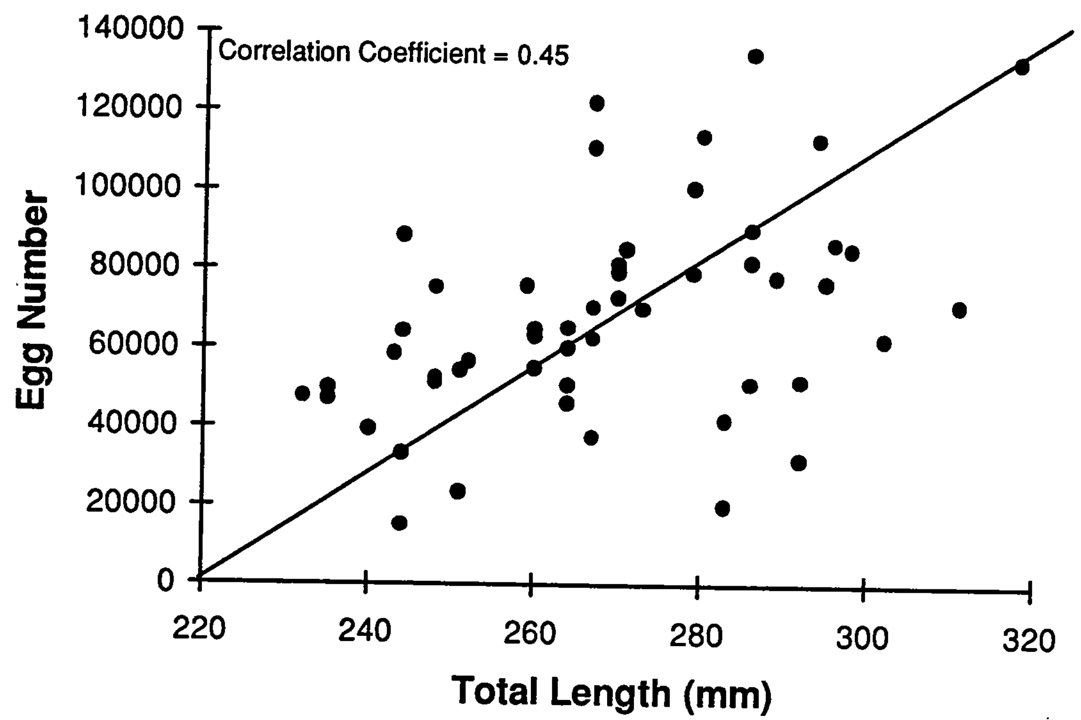


Figure 7. Fecundity of alewives in Quassaic Creek, Newburgh, New York in 1997.

Seven species of fishes were collected in the drift net samples (Table 1). These are the same species collected in drift in Quassaic Creek in 1988 (Schmidt and Limburg 1989) with the addition of yellow perch larvae (*Perca flavescens*) in 1997. Almost 85% of the eggs and larvae collected were alewives, which is typical of Hudson River tributaries in the spring (Schmidt and Limburg 1989).

The total number of alewives estimated from the drift (eggs and larvae) was 3.8 X $10^7$. Although we know that alewife eggs and yolk sac larvae (the only stages seen in this study) have different diurnal drift patterns (Schmidt *et al.* 1994), we calculated the drift as if all the alewives caught were in the egg stage. Alewife yolk



Table 1. Early life stages of fishes collected in the drift from Quassaic Creek, Newburgh, New York, in 1997. Numbers are the totals from three replicate samples on each date. Unidentified eggs are probably cyprinids. Ap = *Alosa pseudoharengus*, Eo = *Etheostoma olmstedi*, Ma = *Morone americana*, Nh = *Notropis hudsonius*, Cc = *Catostomus commersoni*, Ui = unidentified, and Pf = *Perca flavescens*.

| Date | | Ap | Eo | Ma | Nh | Cc | Ui | Pf |
|---|---|---|---|---|---|---|---|---|
| Apr 23 | | 27 | | | | 2 | 2 | |
| May 2 | | 189 | | 3 | 1 | | 1 | |
| May 7 | | 52 | | 1 | | 4 | 3 | |
| May 19 | | 46 | 3 | 3 | | 4 | 3 | 8 |
| May 23 | | 169 | 16 | 13 | 12 | 5 | | |
| May 26 | | 380 | 8 | 32 | 12 | | 4 | |
| May 31 | | 511 | 14 | 2 | 22 | 1 | | |
| Jun 7 | 32 | 6 | 8 | 7 | | | | |
| Jun 8 | 25 | 9 | 9 | 7 | | | | |
| Jun 10 | | 30 | 26 | 1 | 8 | | | |
| Total | | 1461 | 82 | 70 | 69 | 16 | 13 | 8 |

sac larvae were only 9.1% of the total catch. In 1988, we calculated that 9.5 X $10^6$ alewife eggs were produced in Quassaic, 25% of those estimated in 1997.

The estimated number of alewife early life stages in the drift was 23% of the total number of eggs potentially released into Quassaic in 1997. Our calculations do assume that all females that entered Quassaic spawned all their ripe eggs in Quassaic. However, our estimate of female numbers is probably conservative since we did assume we caught all the females from half of the creek mouth (Lake and Schmidt 1997). Regardless, our estimates indicate a 78%
mortality between the time alewives spawned and the capture of eggs and larvae in the drift. Part of this mortality is probably due to egg predation by other fishes in the

spawning areas and, perhaps, by invertebrates. We have often observed fishes like white perch (*Morone americana*) and spottail shiners (*Notropis hudsonius*) mixed in with spawning alewives and we suspect they were consuming alewife eggs. The initially adhesive nature of the eggs and absence of parental care may make them especially vulnerable to benthic-feeding predators.

## DISCUSSION

Our estimates of fecundity differ considerably from published estimates (Kissel 1974; citations in Carlander 1969). Most previous estimates were based on total egg count which ignored the presence of eggs of different sizes. We feel that estimating only the eggs ready to be spawned gave us a more accurate picture of the alewife run in Quassaic Creek because of the physiography of the creek and of Hudson River tributaries in general.

The spawning areas accessible to alewives in Quassaic Creek are within 0.7 km of the tidal creek mouth (Fig. 1). Quassaic Creek is generally shallow and provides little shelter for alewives during the day. Although we have observed alewives in Quassaic Creek in the daytime, we have never seen the numbers of fishes that should be present given our estimates of the magnitude of the run. We interpret these observations as an indication that the adults spend very little time in the creek and are present primarily at night.

Most observations of anadromous alewives (e.g. Kissel 1974) have been made on spawning runs into lakes or ponds where adults have a long residence time (at least



several weeks). The assumption in these situations is that all eggs in an ovary will be spawned in the lentic part of the system, in which case a total count of eggs in the ovaries is the reasonable estimate of egg deposition.

In Quassaic Creek, the proposed short residence time would dictate that only those eggs ready to be spawned would be deposited. In this scenario alewives would be considered iteroparous, maturing a second set of eggs that would be spawned later in the season.

There is some evidence in our data that supports iteroparity. Alewives spawning in Quassaic Creek later in the season had smaller ovaries than those of similar sizes spawning earlier (Fig. 6). If these alewives spawning later in the season are spawning for the second time in the season, there are fewer eggs in the second batch of eggs spawned. Our subjective observations from counting egg subsamples were that the smaller (undeveloped) eggs were less abundant than the larger ones.

## CONCLUSIONS

Our observations on the alewife run in Quassaic Creek are the first in the Hudson River estuary that included population estimates, fecundity estimates, and an estimate of egg and larval mortality. Quassaic Creek is typical of Hudson River tributaries in its size, lack of ponded areas for alewife spawning, and short distances from tidal water in which alewives can spawn. There are also reasons why Quassaic Creek may not be typical of Hudson River tributaries, many of which are correlated with the urban nature of the environment immediately around the creek mouth. We propose the hypotheses that alewives in Hudson River tributaries have a very short residence time on the spawning grounds and that they are iteroparous within a single spawning season.

## RECOMMENDATIONS

Studies like this one need to be repeated in other Hudson River tributaries. Our hypothesis, stated above, needs to be vigorously assaulted. It would be very interesting to estimate the magnitude of alewife egg consumption on the spawning grounds and identify what organisms (vertebrate and invertebrate) may be consuming the eggs while they are adhesive.

## ACKNOWLEDGEMENTS

We thank and express our sincere appreciation to Kathleen Schmidt for drawing some of the figures and to Christopher and Phyllis Lake for helping with sampling in Quassaic Creek. We also thank the Hudson River Foundation and the Hudson River National Estuarine Research Reserve for their continued support and confidence in our efforts.



## REFERENCES

Carlander, K.D. 1969. Handbook of Freshwater Fishery Biology. Vol. 1. Iowa State Univ. Press, Ames. 752 pp.

Kissel, G.W. 1974. Spawning of the anadromous alewife, *Alosa pseudoharengus*, in Bride Lake, Connecticut. Trans. Am. Fish. Soc. 103: 312-317.

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

Schmidt, R.E. 1985. Assessment of the biota of Quassaick Creek. Hudsonia Limited, Annandale, New York.

Schmidt, R.E. 1987. An assessment of Quassaick Creek with suggestions for rehabilitation. Hudsonia Limited, Annandale, New York.

Schmidt, R.E., and S. Cooper. 1995. A catalog of barriers to upstream movement of migratory fishes in the Hudson River tributaries. Final Report to the Hudson River Foundation, New York.

Schmidt, R.E. and K. Limburg. 1989. Fishes spawning in non-tidal portions of Hudson River tributaries. Final Report to the Hudson River Foundation, New York.

Schmidt, R.E., K. Limburg, and T. Stillman. 1994. An estimate of the significance of tributary spawning of alewife (*Alosa pseudoharengus*) to the Hudson River estuary. Pages 23-35 *in* R.E. Schmidt and T. Stillman. Drift of early life stages of fishes in Stockport Creek and significance of the phenomenon to the Hudson River estuary. Final Report to the Hudson River Foundation, New York.

Schmidt, R.E., and T. Stillman. 1994. Drift of early life stages of fishes in Stockport Creek and significance of the phenomenon to the Hudson River estuary. Final Report to the Hudson River Foundation, New York.

Stevens, G., R.E. Schmidt, D.R. Roeder, J.S. Tashiro, and E. Kiviat. 1994. Baseline assessment of tributaries to the Hudson (BATH): Water quality, fishes, macroinvertebrates, and diatoms in Fishkill Creek, Quassaic Creek, and Moodna Creek. Final Report to the Hudson River Improvement Fund of the Hudson River Foundation, New York.

Appendix Table 1. Fishes collected by station in Quassaic Creek, 1996-1997.

| Fish | Station 1 | Station 2 | Station 3 | Station 4 | Station 5 |
|---|---|---|---|---|---|
| American eel, *Anguilla rostrata* | ♦ | ♦ | ♦ | ♦ | |
| blueback herring, *Alosa aestivalis* | ♦ | | | | |
| alewife, *Alosa pseudoharengus* | ♦ | ♦ | ♦ | ♦ | |
| American shad, *Alosa sapidissima* | ♦ | ♦ | | | |
| gizzard shad, *Dorosoma cepedianum* | ♦ | | | | |
| bay anchovy, *Anchoa mitchilli* | | ♦ | | | |
| 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* | ♦ | ♦ | ♦ | | |
| brown trout, *Salmo trutta* | ♦ | | | | |
| brook trout, *Salvelinus fontinalis* | ♦ | | | | |
| eastern banded killifish, *Fundulus diaphanus diaphanus* | ♦ | ♦ | ♦ | | |
| mummichog, *Fundulus heteroclitus* | | ♦ | | | |
| white perch, *Morone americana* | ♦ | ♦ | ♦ | ♦ | |
| striped bass, *Morone saxatilis* | ♦ | ♦ | ♦ | ♦ | |
| rock bass, *Ambloplites rupestris* | ♦ | | | | |
| 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* | ♦ | ♦ | ♦ | ♦ | |
| bluefish, *Pomatomus saltatrix* | | ♦ | | | |
| hogchoker, *Trinectes maculatus* | | ♦ | | | |

Taxa:

| | |
|---|---|
| Families | 14 |
| Genera | 25 |
| Species | 35 |