

Anadromous Fish Survey
Pohick and Accotink Creeks
2008

by

Richard Kraus

Associate Professor
Department of Environmental Science and Policy
George Mason University

Submitted to

Department of Public Works
County of Fairfax, Virginia

June 2009

Background

The commercially valuable anadromous fishes in the herring family (Clupeidae) live as adults in the coastal ocean, but return to freshwater creeks and rivers to spawn. In the mid-Atlantic region, four species are present: American shad, blueback herring, alewife, and hickory shad.

The American shad grows to be the largest and spawns in the shallow flats along the Potomac River channel. In the 1700s and early 1800s, incredibly large numbers of American shad were caught each spring as they came up the river to spawn. The records from 1814-1824 of just one fishery located at Chapman's Landing opposite Mason Neck, Virginia indicate that the annual catch varied from 27,939 to 180,755 American shad (Massmann 1961). By 1982, the numbers caught in the entire river had dwindled so much that a moratorium was placed on both commercial and sport harvest of the species. In 1995, the Interstate Commission on the Potomac River Basin began a process of capturing ripe American shad in gill nets off Dogue Creek and Fort Belvoir, stripping eggs from the females, and fertilizing the eggs with milt from males. The resulting young were raised in hatcheries for several days and then released, as fry, in the river below Great Falls (Cummins 2005). Through the 2002 season, over 15.8 million fry were released into the river, and by 2003 - the year after the restoration program ended - the population was judged strong enough to support a limited commercial fishery as bycatch in gill net fisheries. Moreover, a replacement stocking program continues (Jim Cummins, pers. comm.). The Virginia Department of Game and Inland Fisheries has also released some of the larvae at the boat ramp in Pohick Bay Regional Park in Gunston Cove (Mike Odom, USFWS; pers. comm.).

Prior to the 1900s, spawning occurred in the river as high as Great Falls (Smith and Bean 1899). In recent years spawning has occurred mostly downriver between Piscataway Creek and Mason Neck (Lippson et al. 1979). We do not normally catch individuals of this species as adults, juveniles, or larvae. The adults are not caught because our trawls mostly sample fishes that stay near the bottom of the water column, and the American shad remain in the river where the water column is deeper. The juveniles mostly remain in the channel also, but as reported above, in 2006 and 2007 some juvenile American shad were captured at our seine stations. Hickory shad has similar spawning habitats and co-occurs with American shad, but is far less common than American shad or river herring, and less is known about its life history. Coincident with the appearance of juvenile American shad at our seine stations, we have also observed small numbers of juvenile hickory shad in recent years.

The alewife and blueback herring, collectively called river herring, are commercially valuable, although typically less valuable than American shad. In past centuries, their numbers were apparently even greater than those of the American shad. Massmann (1961) reported that from 1814 to 1824, the annual catch at Chapman's Landing ranged from 343,341 to 1,068,932 fish. The alewife spawns in tributary creeks of the Potomac River and travels farther into these creeks than do the other species. The blueback herring also enters creeks to spawn, but may also utilize downstream tidal embayments to spawn.

Although there are no restrictions on their harvest in the Potomac, river herring were listed in 2006 by NOAA as species of concern due to widespread declining population indices. Population indices of river herring in the Potomac are available from seine surveys of juveniles conducted by MD-DNR. Juvenile catch rate indices are highly variable but have been lower in the most recent decade for both species (blueback herring mean: 1998-2008=0.77 vs. 1959-1997=1.57; alewife mean: 1998-2008=0.35 vs. 1959-1997=0.55). This pattern is not reflected in

the seine and trawl catches in Gunston Cove, which have fluctuated very little or increased slightly since the inception of the survey. While the DNR indices may represent a basin wide pattern, it is not yet possible to determine the relative contribution of juveniles from Pohick and Accotink Creeks to the Gunston Cove or DNR surveys. Such information would provide a better understanding of the population dynamics of specific tributaries.

Another set of economically valuable fishes are the semi-anadromous white perch and striped bass, which are sought after by both the commercial fishery and the sport-fishery. Both spawn in the Potomac River. Striped bass spawn primarily in the river channel between Mason Neck and Maryland Point, while white perch spawn primarily further upriver, from Mason Neck to Alexandria, and also in the adjacent tidal embayments (Lippson et al. 1979). Although spawning is concentrated in a relatively small region of the river, offspring produced there spread out to occupy habitats throughout the estuary (including surf-zone habitats of barrier islands in some years; Kraus, personal observation). These juveniles generally spend the first few years of life in the estuary and may adopt a seasonal migratory pattern when mature. While most striped bass adults are migratory (spending non-reproductive periods in coastal seas), recent work indicates that a significant (albeit small) proportion of adults are resident in the estuaries. Specific information about striped bass migratory patterns in the Potomac is lacking.

Two other herring family species are semi-anadromous and spawn in the area of Gunston Cove. These are the gizzard shad and the threadfin shad. Both are very similar morphologically and ecologically, but in our collections, threadfin shad are found downriver of Mason Neck, and gizzard shad are found upriver of Mason Neck. Neither is commercially valuable, but both are important food sources of larger predatory fishes.

For several years, we have focused a monitoring program on the spawning of these species in Pohick Creek, Accotink Creek, and, less regularly, Dogue Creek. We have sampled for adult individuals each spring since 1988 and for eggs and larvae since 1992. After 16 years of using hoop nets to capture adults, we shifted in the spring of 2004 to visual observations and seine, dip-net, and cast-net collections. This change in procedures was done to allow more frequent monitoring of spawning activity and to try to determine the length of time the spawning continued. We had to drop Accotink Creek from our sampling in 2005, 2006, and 2007 because of security-related access controls at Fort Belvoir. Fortunately, access to historical sampling locations from Fort Belvoir was regained in 2008 and 2009. Results for 2008 sampling are presented below, and 2009 samples are still being processed. A summary of historical results was provided in the 2007 annual report for this project, and an analysis and synthesis of these data to determine seasonal spawning periodicity and long-term trends is currently in preparation.

Introduction

Since 1988, George Mason University researchers have been surveying spawning river herring in Pohick Creek and adjacent tributaries of the Potomac River. The results have provided information on the annual occurrence and seasonal timing of spawning runs for alewife (*Alosa pseudoharengus*) and blueback herring (*A. aestivalis*), but inferences on abundance have been limited for several reasons. The amount of effort to sample spawners has varied greatly between years and the methods have changed such that it is difficult to standardize the numbers captured or observed in order to understand annual fluctuations in abundance. In addition, ichthyoplankton sampling in the creeks has been contemporaneous with spawning runs, and thus it has not reflected outdrift of larvae which may continue after the spawners leave. River discharge was also not measured during the previous ichthyoplankton sampling. To maintain coherence with historical efforts while increasing the value of the data from surveys of Pohick

and Accotink Creeks, we developed a modified protocol with two main objectives: 1) quantify the magnitude of outdrifting larvae and coincident creek discharge rate in order to calculate total larval production; 2) quantify seasonal spawning run timing, size distribution and sex ratio of adult river herring using hoop nets (a putatively non-selective gear used throughout the majority of the survey). These modifications were accomplished with little additional cost and provided results that are more comparable to assessments in other parts of the range of these species. Quantico and Dogue creeks were also sampled previously, but the frequency was more sporadic. Due to logistics and expense required to conduct comparable sampling efforts, we did not attempt any sampling at Quantico and Dogue creeks and instead focused entirely on Pohick and Accotink creeks.

Methods

We conducted approximately weekly sampling trips from April 15th to May 19th in 2008. Although our goal was to begin sampling in March and we submitted a request for access in January, the permitting process was delayed. Sampling locations in each creek were located near the limit of tidal influence and as close as possible to historical locations. On one day each week, we sampled ichthyoplankton by holding a conical plankton net with a mouth diameter of 0.25 m and a square mesh size of 0.333 mm in the stream current for 10 minutes. A mechanical flow meter designed for low velocity measurements was suspended in the net opening and provided estimates of water volume filtered by the net. Depending upon flow conditions (we only sampled where creek depth allowed complete submergence of the net opening), we collected 2 to 3 ichthyoplankton samples per week in each creek, and these were spaced out evenly along the stream cross-section. Coincident with plankton samples, we calculated stream discharge rate from measurements of stream cross-section area and current velocity (at 2 to 5 locations along the cross-section). The ichthyoplankton samples were preserved in 10% formalin and transported to the GMU laboratory for identification and enumeration of fish larvae. Identification of larvae was accomplished with multiple taxonomic resources: primarily Lippson & Moran (1974), Jones et al. (1978), and Walsh et al. (2005). River herring (both species) have demersal eggs (tend to sink to the bottom) that are frequently adhesive. As this situation presents a significant bias, we made no attempts to quantify egg abundance in the samples. We estimated total larval production (P) in each creek using the formula: $P = D * V * I$, where D is the density of larvae (per cubic meter), V is the mean river discharge rate (cubic meters per second), and I is the sampling period in seconds.

The hoop net was deployed once each week in the morning and retrieved the following morning (see **Picture 1**). All fish in the hoop net were identified, enumerated, and measured. Any river herring were retained for reproductive examination in the laboratory, while all other species were released. To obtain creek-specific information on fecundity, we attempted to quantify oocytes from our samples. Unfortunately, gravid females were in running ripe (i.e., with hydrated oocytes) or spent condition, making fecundity estimates from our samples unreliable. Instead we used published estimates of fecundity and observed sex ratios in our catches to estimate spawner abundance. Spawner abundance (A) was estimated for river herring species and gizzard shad (a sympatric anadromous species with similar spawning behavior) using the formula: $A = P / (R * S)$, where R is the mean fecundity based upon mean female size in the catch, and S is the observed sex ratio (female:male). Alewife fecundity estimates were derived from Kissil (1974), using an unpublished length conversion from this work where fork length = 0.88 * total length. In addition, we adjusted fecundity for alewife based upon Jessop (1993), who estimated that the number of eggs actually spawned is 0.67% of the total fecundity estimated from oocyte counts in gonad samples. Less reproductive information for gizzard shad

was available and we did not evaluate sex ratio in the catches because the gizzard shad were released alive. For estimates of gizzard shad spawner abundance we used size-based estimates of fecundity derived from landlocked populations as reported by Jons & Miranda (1997) and Michaletz (1998) and assumed a sex ratio of 50% female. This was accomplished by using the formula from the lake with the largest sample size in Michaletz (1998) and scaling the result by the expected mean proportion of eggs >0.65 mm diameter (i.e., “functional fecundity” in Jons & Miranda, 1997).

On nearly every sampling date, we found that some being had torn holes in the nets. Tracks along the shore, bite marks on fishes in the nets, and consultation with natural resource assessment staff at Fort Belvoir indicated that river otters (which have recently increased in abundance in these areas) were the likely cause. To keep out otters, we covered the outside of the net in poultry fencing, but this was not successful. At the last sampling date, we erected a scarecrow to deter the otters, but this may have had little effect because the spawning run had already ended¹. This issue clearly reduced the numbers of fish in our samples, but we cannot determine the magnitude of the bias. The main assumption (which we cannot test) is that the river otter actions did not bias the sex ratio or size distribution results.



Picture 1. Hoop net deployed in Pohick creek. The top of the hoop net is exposed at both high and low tide to avoid drowning turtles, otters, or other air-breathing vertebrates. The hedging is angled downstream in order to funnel up-migrating herring into the opening of the net. The scarecrow was used to deter river otters from entering the net.

Results

Our creek sampling work in 2008 spanned a total of 6 weeks, during which we collected 34 ichthyoplankton samples, and 44 adult alewife in spawning condition. We did not observe any adult blueback herring. The two river herring species are remarkably similar during both larval and adult stages, and distinguishing larvae can be extraordinarily time consuming. Thus, for purposes of larval identification we assumed that all *Alosa* larvae were *A. pseudoharengus* (alewife). In addition, there was a remote possibility that two *Dorosoma* species could be present in our samples, and these are also extremely difficult to distinguish as larvae. Due to the absence of juveniles in seine and trawl samples from the adjacent Gunston Cove and adjacent Potomac River, we disregarded the possibility that threadfin shad (*D. petenense*) were present in our ichthyoplankton samples.

¹ **Note:** During the 2009 sampling season, we deployed scarecrows and poultry fencing on every sampling trip, but still had problems with otters making holes in the nets. Through trial and error, we have designed and tested an otter excluder device that appears to work well. This will be discussed along with 2009 results in the next annual report.

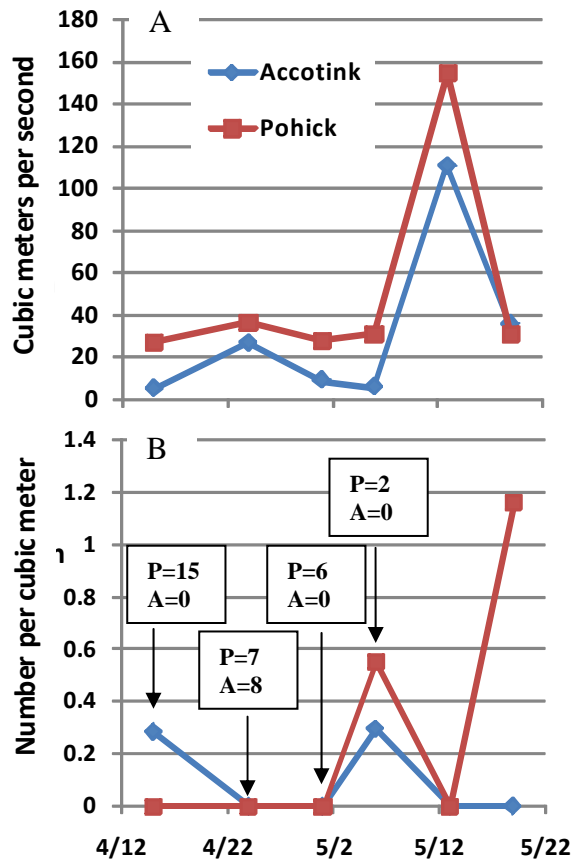


Figure 1. Discharge rate (A) and density of larval alewife (B) observed in Pohick and Accotink creeks during April and May of 2008. Boxes in the lower panel indicate numbers of adults in hoop net catches for Pohick (P) and Accotink (A) creeks.

was estimated at approximately 9 and 43 million for Accotink and Pohick creeks, respectively. *Dorosoma* density was lower on average leading to total larval production estimates of 62 thousand for Accotink creek and 14 million for Pohick creek.

In part because of problems with otters, numbers of adults in hoop nets were very low. Only 38 alewife (15 female) were captured in Pohick Creek, and only 8 (2 female) were captured in Accotink Creek. These numbers were too low to support creek specific sex ratio estimation; therefore, the pooled sex ratio for both creeks was used to estimate spawner abundance. Based upon observed mean female fork lengths, sex ratios, total larval production, and published estimates of fecundity (see Methods), the abundance of spawning alewife was estimated to be 202 in Accotink Creek and 544 in Pohick Creek during the period of sampling. By comparison, there was greater variability between creeks for gizzard shad spawner abundance estimates, which ranged between 5 and 1270 for Accotink and Pohick Creeks, respectively. Because the mortality rates of eggs and newly hatched larvae are unknown from these systems, these estimates should be considered minimum conservative values. Any adjustment for egg or post-hatch mortality would tend to increase the estimate of spawner abundance. In addition for gizzard shad, a sex ratio skewed in favor of males (as we observed for alewife) would also tend to increase the estimated total spawner abundance, but this information was not collected in order to release gizzard shad as part of the hoop net by-catch.

Densities of both alewife and gizzard shad were very low in 2008 creek ichthyoplankton samples. In total our samples yielded only 27 *Alosa* larvae and 39 *Dorosoma* larvae. These values were at the low end of the range of larval counts from previous sampling, and in specific years, counts in the hundreds have been observed for these species (see previous annual report). Additionally, we recorded 19 sucker larvae (family Catostomidae), 17 minnow larvae (family Cyprinidae), and 2 white perch (*Morone americana*) larvae (pooled across creeks). In these data, we had the advantage of measurements of river discharge measured at the same locations and times where ichthyoplankton samples were taken. River discharge was consistently higher in Pohick creek (except for the last sampling date) and ranged between 5.7 and 154 m³s⁻¹ (Figure 1). Larval density was variable and low for both *Alosa* (Figure 1) and *Dorosoma* (not shown) and did not indicate a clear peak spawning period. The highest density of *Alosa* larvae was 1.16 m⁻³ in Pohick creek at the last sampling date (Figure 1). Averaged across the entire sampling period of 34 days, the total discharge was estimated to be on the order of 94 and 149 million cubic meters for Accotink and Pohick creeks, respectively (Table 1). Given the observed mean densities of larvae, the total production of larvae

Table 1. Estimation of alewife and gizzard shad spawner abundance from Accotink and Pohick creeks during spring 2008.

	<u>Accotink Creek</u>	<u>Pohick Creek</u>
Mean discharge (m ³ /s)	32.07	51.05
Total discharge, 4/15 to 5/19 (m ³)	94,219,914	149,967,745
<u>Alewife</u>		
Mean density of larval <i>Alosa</i> (m ⁻³)	0.096	0.285
Total larval production	9,045,621	42,697,302
Adult alewife mean fork length (mm)	230	245
Alewife fecundity	68919	120668
Sex ratio (F:M)	0.59	0.59
Number of female alewife	131	354
Total number of alewife	202	544
<u>Gizzard shad</u>		
Mean density of larval <i>Dorosoma</i> (m ⁻³)	0.00681	0.320
Total larval production	61,639	13,650,043
Adult gizzard shad mean total length (mm)	384	353
Gizzard shad fecundity	24782	21503
Sex ratio (F:M, assumed equal)	0.5	0.5
Number of female gizzard shad	2	635
Total number of gizzard shad	5	1270

Discussion

Despite problems with marauding otters and delayed access to sampling locations, the results from the modified creek sampling protocol provided important insights about anadromous clupeid spawning (especially alewife) in Pohick and Accotink Creeks. In 2008 and throughout the history of the survey, the consistent presence of alewife and lack of blueback herring suggests that Pohick and Accotink Creeks are a more suitable habitat for alewife (at least during the past 3 decades). The presence of spent and running ripe females in our catches also indicates that some spawning is occurring in tidal areas downstream. The importance of upstream spawning locations relative to tidal habitats is simply unknown for these systems, but previous work in other systems indicates that the most important spawning areas typically occur upstream of the influence of tides for river herring. The low catches of adults in hoop nets mirrors the low estimates of total spawner abundance from larval data (Table 1), indicating that the number of alewife in either creek during the 6 weeks in which sampling took place was in the hundreds. Consistently higher numbers of alewife and gizzard shad spawners suggests that Pohick Creek provides a more productive spawning habitat for anadromous clupeids. The longer-term trend for lower counts of adults in hoop nets and lower larval counts also reflects declining indices of abundance from throughout the range of this species. Due to the recent (NOAA, 2006) listing of river herring as species of conservation concern, annual estimation of spawner abundance should be a continued priority for annual monitoring in these creeks.

Several factors contribute to uncertainty of the estimates of spawner abundance. Although some of these can be addressed with modifications of sampling protocol, other factors are beyond the scale of this project to address. Contributing to the low values of spawner abundance, we missed a potentially significant contribution from adults spawning in March and early April. It is also possible (but less likely) that late spawners were present at the end of May and June. Our weekly sampling efforts were adjusted based upon military training schedules at

Fort Belvoir and flood events that prevented safe deployment of sampling gear. Our sampling approach provides information about low to moderate flow conditions only with no ability to examine higher frequency (< weekly) patterns. Alewife spawning, egg development, and hatching may happen in as little as 3 to 7 days; therefore, it is possible to miss a peak spawning event between sampling dates and during flood events. Unfortunately, given the logistical constraints of access to our sites through military controlled training areas, it is unlikely that we would be able to address this potential bias in future efforts.

Finally, low larval densities for alewife as well as the other species raises questions about the efficacy of the sampling approach. On the one hand, anadromous fishes typically exhibit strong year-class fluctuations, and reproductive success of freshwater spawning fishes (anadromous and otherwise) is strongly correlated with freshwater flow (Wood & Austin 2009). The year 2008 can be generally characterized as a low-flow year for the Potomac and its tributaries, which provides a potential explanation for the low larval density. However, flows in May were well above average. On the other hand, we do not have any comparable estimates from other years for these systems to evaluate the creek-specific variability in spawner abundance, larval export, or correlations with discharge and juvenile abundance. At the very least, results from 2009 sampling and future years will be needed to address such questions.

Literature cited

- Cummins, J.D. 2005. The Potomac River American shad restoration project. 2004 Summary Report. Interstate Commission on the Potomac River Basin Report No. 05-2. 6 + 3 p.
- Jessop B.M. 1993. Fecundity of Anadromous Alewives and Blueback Herring in New-Brunswick and Nova-Scotia. Transactions of the American Fisheries Society 122:85-98
- Jones, P. W., F. D. Martin, and J. D. Hardy, Jr. 1978. Development of fishes of the Mid-Atlantic Bight: an atlas of egg, larval, and juvenile stages, volume 1. Acipenseridae through Ictaluridae. U.S. Fish and Wildlife Service, FWS/OBS-78/12.
- Jons, G.D., and L.E. Miranda 1997. Ovarian weight as an index of fecundity, maturity, and spawning periodicity. Journal of Fish Biology 50:150-156
- Kissil, G.W. 1974. Spawning of the anadromous alewife, *Alos pseudoharengus*, in Bride Lake, Connecticut. Transactions of the American Fisheries Society 103:312-317.
- Lippson, A. J., M. S. Haire, A. F. Holland, F. Jacobs, J. Jensen, R. L. Moran-Johnson, T. T. Polgar, and W. A. Richkus. 1979. Environmental atlas of the Potomac Estuary. Environmental Center, Martin Marietta Corp. 280 p.
- Lippson, A. J., and R. L. Moran. 1974. Manual for the identification of early developmental stages of fishes of the Potomac River estuary. Maryland Department of Natural Resources, Baltimore.
- NOAA (Department of Commerce). 2006. Endangered and Threatened Species; Revision of Species of Concern List, Candidate Species Definition, and Candidate Species List. Federal Register, Vol. 71, No. 200, Tuesday, October 17, 2006, pp. 61022-61025.
- Massmann, W.H. 1961. A Potomac River shad fishery, 1814 – 1824. Chesapeake Sci. 2 (1-2): 76-81.
- Michaletz, P.H. 1998. Effect of body size on fecundity, the gonadosomatic index, egg size, and timing of spawning of gizzard shad. Journal of Freshwater Ecology 13(3):307-315.
- Smith, H.M., and B.A.Bean . 1988. List of fishes known to inhabit the waters of the District of Columbia and vicinity. U.S. Fish Commission Bulletin 18:179-187.

- Walsh H.J., L.R Settle, and D.S. Peters. 2005. Early life history of blueback herring and alewife in the lower Roanoke River, North Carolina. *Transactions of the American Fisheries Society* 134:910-926.
- Wood, R.J., and H.M. Austin. 2009. Synchronous multidecadal fish recruitment patterns in Chesapeake Bay, USA. *Canadian Journal of Fisheries and Aquatic Sciences* 66:496-508.