## *Anadromous Fish Survey 2012*

### 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. Since 2010, we have been catching hickory shad adults in Pohick Creek and Accotink Creek.

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.

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). Since declines continued, a moratorium was established in January 2012, restricting all catches of alewife and blueback herring (4VAC 20-1260-20). Causes of river herring decline are likely a combination of long-term spawning habitat degradation and high mortalities as a result of bycatch in the menhaden fishery. The establishment of a moratorium indicates that declines are widespread, and regular fishing regulations have not been sufficient to rebuild the stock. Using a moratorium to rebuild the stock is also an indication that the cause of the decline is largely unknown. One planned PhD project is to develop a population model using these data collections to help determine the status of the stock, the cause of the decline and the effect of the moratorium.

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.

Two other herring family species are semi-anadromous and spawn in the area of Gunston Cove. These are gizzard shad (*Dorosoma cepedianum*) and threadfin shad (*Dorosoma petenense*). 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. The hoop net methodology was taken up again in 2008 and has been continued weekly from mid-March to mid-May each year since then. The creeks continuously sampled with this methodology during this period are Pohick Creek and Accotink Creek. Results for 2012 sampling are presented below. A summary of historical results was provided in the 2007 annual report for this project, an update of this summary will be provided in the 2013 report.

**Introduction**

Since 1988, George Mason University researchers have surveyed 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. 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 in 2008 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. We have continued this sampling protocol in 2012 in Pohick Creek and Accotink Creek.

**Methods**

We conducted weekly sampling trips from March 9$^{th}$ to May 11$^{th}$ in 2012. 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 two 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 20 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. The number of rotations of the flow meter attached to the net opening was multiplied with a factor of 0.01 (R.C. Jones, pers. comm.) to gain volume filtered ($m^3$). We collected 2 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 using the following equation:

Depth (m) x Width (m) x Velocity (m/s) = Discharge ($m^3$/s)

Velocity was measured using a handheld digital flow meter that measures flow in cm/s, which had to be converted to m/s to calculate discharge. Both depth and current velocity were measured at 12 to 20 locations along the cross-section.

The ichthyoplankton samples were preserved in 70% ethanol 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 were able to estimate total larval production (P) during the period of sampling by multiplying the larval density ($m^{-3}$) with total discharge ($m^3$) (Table 1).

The hoop net was deployed once each week in the morning and retrieved the following morning (see Figure 1). All fish in the hoop net were identified, enumerated, and measured. Fish which were ripe enough to easily express eggs or sperm/semen/milt were noted in the field book and in the excel spreadsheet. This also determined their sex. Any river herring that had died or were dying in the net were kept, while all other specimens were released. Fish that were released alive were only measured for standard length to reduce handling time and stress. Dead and dying fish were measured for standard length, fork length and total length. The dead fish were taken to the lab and dissected for ID and sex confirmation.

We used a published regression of fecundity by size and observed sex ratios in our catches to estimate spawner abundance. The following regression to estimate fecundity was used, this regression estimates only eggs ready to be spawned, giving a more accurate picture than total egg count (Lake and Schmidt 1997):

Egg # = -90,098 + 588.1(TL mm)

We used data from specimens where both standard length and total length was estimated to convert standard length to total length in cases we had not measured total length. Our data resulted in the following conversion: TL = 1.16SL + 6. The regression had an $R^2$ of 0.97.

Since the nets were set 24 hours per week for 10 weeks, we approximated total abundance of spawning alewife and gizzard shad during the time of collection by extrapolating the mean catch per hour per species during the time the creeks were blocked of over the total collection period as follows:

Total catch/240 hours * 1680 hours = total abundance of spawners

Our total collection period is a good approximation of the total time of the spawning run of alewife. To determine the number of females we used the proportion of females in the catch for alewife, and used a ratio of 0.5 for gizzard shad as we were unable to sex gizzard shad that were all released alive.

This year we did not determine the abundance of spawners based on the amount of larvae collected. Alewife and gizzard shad have fecundities of 60,000-120,000 eggs per female, and with the low numbers of larvae collected, we would grossly underestimate the abundance of spawning fish. Eggs and larvae also suffer very high mortality rates, so it is unlikely that 60,000-120,000 larvae suspended in the total discharge of a creek amount to one spawning female.

In response to problems with animals (probably otters) tearing holes in our nets in previous years, we used the fence device again that significantly reduced this problem last year. The device effectively excluded otters and similar destructive wildlife, but had slots that allowed up-running fish to be captured. The catch was primarily Clupeids with little or no bycatch of other species.

**Figure 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.

## Results

Our creek sampling work in 2012 spanned a total of 10 weeks, during which we collected 40 ichthyoplankton samples, and a number of adult alewife in spawning condition. In 2010 hickory shad (*Alosa mediocris*) was captured for the first time in the history of the survey, and we captured 16 in 2011 and 3 in 2012. Hickory shad are known to spawn in the mainstem of the Potomac River, and although their ecology is poorly understood, populations of this species in several other systems have become extirpated or their status is the object of concern. We captured 3 hickory shad in Pohick Creek and none in Accotink Creek. We observed one blueback herring in Pohick Creek and none in Accotink Creek. The two river herring species (blueback herring and alewife) 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 were present in our ichthyoplankton samples.

Densities of alewife and other alosids were lower in 2012 creek ichthyoplankton samples than they were in 2011. In total our samples yielded 36 *Alosa* larvae (91 last year). The number of Alosa larvae was so low, that we did not use the number of larvae to determine the total number of Alewife. Alewife can produce 60,000 to 100,000 larvae per specimen; when we use the number of larvae collected to calculate the number of spawning alewife this results in an incredibly low number. Instead we calculated the total number of alewife by multiplying the number of alewife we caught in 24 hours by the length of time of our sampling period (as a proxy for the spawning season).

*Dorosoma* sp. were still the most abundant, but much less abundant than last year. We captured 181 *Dorosoma* in 2012 compared to 1507 in 2011. 2011 was a year with exceptionally high abundances compared to other recent years; 2012 is close to what was observed in 2010. Although it is not considered unusual to observe order-of-magnitude fluctuations in larval density, Accotink Creek yielded very low numbers of both adult and larval fish. Because the creek is split in two branches at the sampling site, one ichthyoplankton net will be moved to the second branch of the creek in the 2013 sampling season to determine if spawning has moved to the other branch. Tropical storm Lee has caused some changes in the landscape, which could have resulted in a change of spawning habitat choice of anadromous fishes. If the second branch indeed is more productive based on the ichthyoplankton samples, the hoop net (to catch adults) will be moved to the second branch as well. In addition to *Alosa* and *Dorosoma* larvae, we recorded 2 sucker larvae (family Catostomidae), 42 minnow larvae (family Cyprinidae), 3 perch larvae (*Percidae*), 1 largemouth bass larvae (familiy Centrarchidae), and 8 Morone larvae (*Morone americana and M. saxatilis).*

We measured creek discharge at the same locations and times where ichthyoplankton samples were taken. Creek discharge was consistently higher in Pohick creek than Accotink creek and ranged between 0.96 and 2.05 $m^3 s^{-1}$ (Figure 2a). Larval density for *Alosa* was overall lower than 2011, and exhibited a peak on April 6 in Pohick Creek; the only recording of larvae in Accotink Creek on March 30 (Figure 2b). *Dorosoma* (not shown) larval density showed a very high peak on May 11 in Pohick Creek, and very low numbers (0 or 1) throughout the sampling season in Accotink Creek.

Averaged across the entire sampling period of 70 days, the total discharge was estimated to be on the order of 2 and 8 million cubic meters for Accotink and Pohick creeks, respectively (Table 1). Given the observed mean densities of larvae, the total production of *Alosa* larvae was estimated at approximately 13 and 300 thousand for Accotink and

Pohick creeks, respectively. *Dorosoma* density was higher leading to total larval production estimates of 13 thousand and 300 thousand for Accotink and Pohick creeks, respectively. The numbers are lower than 2011, but similar to 2010.

In the hoop net sets, a total of 113 alewife were captured. Only 63 Alewife were sexed; of those 21 were female and 42 were male. Skewed sex ratios in fish populations are common. The total abundance of spawning alewife was estimated to be 441 in Pohick Creek during the period of sampling, and 84 in Accotink creek. We caught few adult gizzard shad this year; a total of 7 gizzard shad were captured in the hoop nets. Total gizzard shad spawning abundance during the sampling season was estimated to be 14 in Accotink and 35 in Pohick creek.

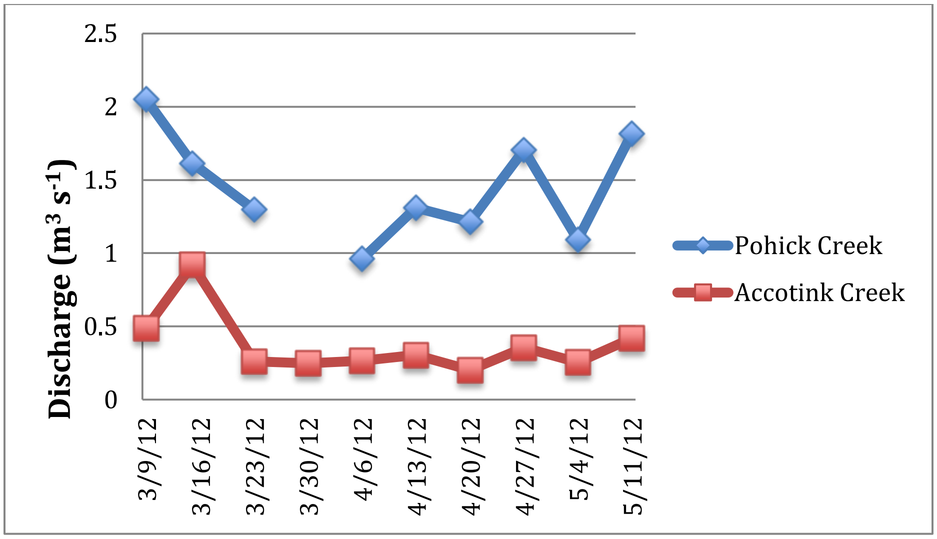


**Figure 2a.** Discharge rate measured in Pohick and Accotink creeks during 2012.

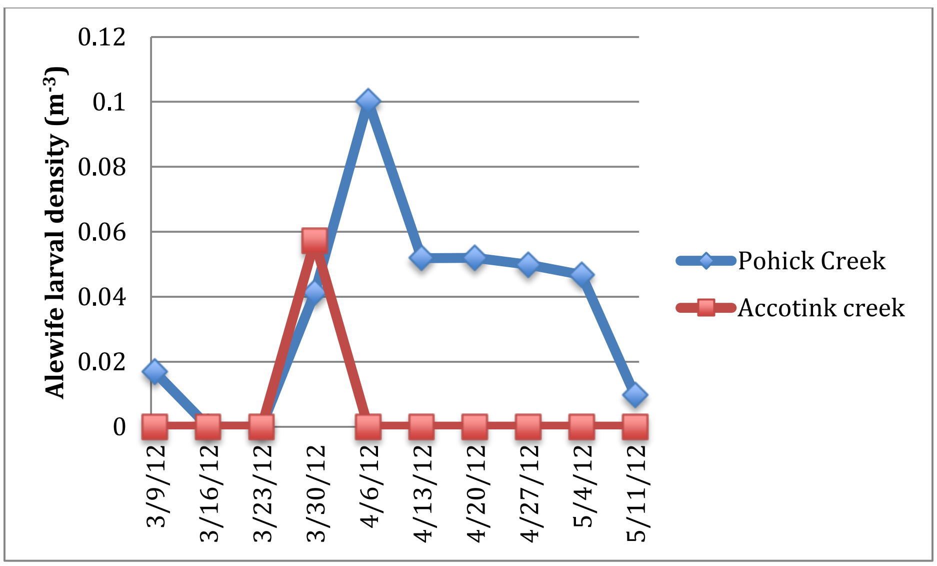


**Figure 2b.** Density of larval alewife observed in Pohick and Accotink creeks during 2012.

**Table 1.** Estimation of alewife and gizzard shad fecundity and spawner abundance from Accotink and Pohick creeks during spring 2012.

| | Accotink Creek | Pohick Creek |
|---|---|---|
| Mean discharge ($m^3/s$) | 0.37 | 1.45 |
| Total discharge, 3/9 to 5/11 ($m^3$) | 2,237,760 | 8,769,600 |
| Alewife | | |
| Mean density of larval *Alosa* ($m^{-3}$) | 0.006 | 0.037 |
| Total larval production | 13,426.56 | 324,475.2 |
| Adult alewife mean standard length (mm) | 205 | 229 |
| Alewife fecundity | 52,222 | 69,748 |
| Sex ratio (proportion female) | 0.22 | 0.17 |
| Number of female alewife | 19 | 78 |
| Total number of alewife | 84 | 441 |
| Gizzard shad | | |
| Mean density of larval *Dorosoma* ($m^{-3}$) | 0.039 | 0.122 |
| Total larval production | 87,272.64 | 1,069,891.2 |
| Gizzard shad mean standard length (mm) | 286 | 311 |
| Gizzard shad fecundity | 108,539 | 115,737 |
| Sex ratio (%F) | 0.5 | 0.5 |
| Number of female gizzard shad | 7 | 18 |
| Total number of gizzard shad | 14 | 35 |

## Discussion

Our modifications to the hoop nets to exclude destructive bycatch (namely, otters) appear to be successful as net tears and suspected loss of catch were minimal in 2012. Further, the capture of adult hickory shad, which are similar in shape but approximately twice as large as the largest alewife, provides convincing evidence that the bycatch excluder is not affecting capture of the target species, adult river herring. We caught one blueback herring in addition to alewife, which is new for this survey. We are now dissecting clupeids that were caught in previous years to determine if this is really a first or if more blueback herring were caught but misidentified in previous years. A summary over multiple years that is currently in preparation will include any findings of blueback herring in previous years. This summary will be presented in the 2013 report. 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 unknown for these systems. Though previous work in other systems indicates that the most important spawning areas typically occur upstream of the influence of tides for river herring, this could potentially change over time. We will analyze whether recordings of spent females have gone up in recent years, since a relocation of spawning habitat may be another component of the low catches of adults and larvae in 2012 (in addition to widespread population decline). Catches were lower than 2011 and similar to 2010. Larvae were collected again in Accotink (though in low numbers), so the absence of larvae and therefore the estimation of zero spawning abundance in 2010 was an anomaly. The number of spawning alewife is low but still fall within the range found in previous years with 84 and 441 estimated spawning alewife in Accotink Creek and Pohick Creek respectively. Considering the phenomenal numbers of herring and shad captured in fisheries in previous centuries (see Massmann 1961), these creeks probably only ever represented an extremely small fraction of the total larval production of herring and shadin the Potomac River.

Gizzard shad catches were lower than last year as well. Gizzard shad is not an anadromous fish like the *Alosa* sp., and therefore they are not purposely swimming upstream to spawn (which is when fish are caught in our net). Therefore the catch of gizzard shad can be highly variable, and is dependent on the behavior of a local population.

To understand the contemporary importance of these systems, comparative work in other tributaries and the Potomac mainstem is needed.  Starting in 2013, we will have the ability to compare our results with one other stream, Cameron Run, which we will sample as part of a different study using the same protocol as in Accotink and Pohick Creek. For comparisons with other tributaries, we will work on gathering information collected by other agencies such as MD-DNR. Between Accotink and Pohick Creek, consistently higher numbers of alewife and gizzard shad spawners have been collected at Pohick creek, suggesting that Pohick Creek provides a more productive spawning habitat.  Due to the recent moratorium on river herring, annual estimation of spawner abundance should be a continued priority for annual monitoring in these creeks. In addition, NMFS is considering a petition (submitted by the Natural Resources Defense Council; NRDC, 2011) to list river herring as a threatened species.

Several factors contribute to uncertainty of the estimates of spawner abundance, especially if based on the amount of suspended larvae collected. This year total spawner abundance is determined using the hoop net catches of adults. Because the nets are set for 24 hours, both day-time and night-time conditions are included, which is not the case with ichthyoplankton collections. In additions, mortality among early life stages is very high, making estimates of adults based on adult fecundity in combination with larval densities very uncertain. Since we collect adults, and completely block the creek for 24 hours when we do, it is a more reliable and straightforward approach to estimate the total number of adults based on our adults collections than based on our larval collections.

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 low flow in 2012, especially compared to 2011, likely contributed to the lower larval densities of alewife and gizzard shad in both Accotink and Pohick creek. Additional years of data collection (at least through 2 generation lengths of alewife ~ a decade), should provide a sufficient understanding of this variability. The collections of specimens itself is important too, and alewife collected in Accotink and Pohick creek are currently used to create a population model (by for example analyzing age, growth and spawning frequency using the scales and otoliths of the collected specimens) that will provide more insight in alewife population dynamics, and potential causes of decline in stock abundance. Although the current evidence suggests that the importance of Pohick and Accotink creeks may be marginal to alewife populations, it is important to recognize that marginal habitats may sustain fish populations during periods of declining abundance and low recruitment (Kraus and Secor 2005). This may be particularly important when considering that Pohick and Accotink creeks are less impacted than some other tributaries of the Potomac River where alewife are known to spawn.

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