Anadromous Fish Survey 2011

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 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 nets methodology was taken up again in 2008 and continued in 2011. Results for 2011 sampling are presented below. A summary of historical results was provided in the 2007 annual report for this project.

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 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 2011, and as in 2010, we did not attempt any sampling at Quantico and Dogue creeks but instead focused entirely on Pohick and Accotink creeks.

Methods

We conducted approximately weekly sampling trips from March 16th to May 24th in 2011. 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). Depending upon flow conditions (we only sampled where creek depth allowed complete submergence of the net opening), 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 (at 12 to 20 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 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.

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. Our data resulted in the following conversion: TL = 1.16SL + 6. The regression had an R^2 of 0.97.

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 *P* is total larval production, *R* is the mean fecundity based upon mean female size in the catch, and *S* is the observed sex ratio (proportion female). We did not evaluate sex ratio in the catches of gizzard shad because they were released alive, so we assumed a sex ratio of 50% 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 2011 spanned a total of 11 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. 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. In 2011, we captured 16 hickory shad again, both in Pohick and in Accotink creek. 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 were present in our ichthyoplankton samples.

Densities of alewife and other alosids were higher in 2011 creek ichthyoplankton samples than they were in 2010. In total our samples yielded 91 *Alosa* larvae (35 last year). *Dorosoma* sp. Were still the most abundant, and much more abundant than last year. We captured 1507 *Dorosoma* in 2011 compared to 79 in 2010. The *Alosa* values were higher than 2010 but average compared to larval counts from previous sampling; in some years counts in the hundreds have been observed for these species (see previous annual reports). Alewife densities can also vary widely across weeks within a year and between years, and due to natural fluctuations in spawning processes and egg and larval survival, it is not considered unusual to observe order-of-magnitude fluctuations in larval density. The high number of Dorosoma larvae is likely a function of the high discharge both creeks experienced in 2011 (Figure 2a). A larger volume of water is sampled in the same 20 minutes if the discharge is higher. In addition to *Alosa* and *Dorosoma* larvae, we recorded 83 sucker larvae (family Catostomidae), 57 minnow larvae (family Cyprinidae), 7 yellow perch larvae (*Perca flavescens*), 4 largemouth bass larvae (familiy Cenrarchidae), and 1 silverside larvae (*Menidia* sp.).

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 26 and 341 $m^3 s^{-1}$ (Figure 2a). Larval density for *Alosa* was overall higher than 2010, and exhibited a peak on May 4 in Accotink, and March 30 and May 12 in Pohick creek (Figure 2b). *Dorosoma* (not shown) larval density showed a very high peak on April 27 in Accotink, and a lower peak on May 12 in Pohick.

Averaged across the entire sampling period of 71 days, the total discharge was estimated to be on the order of 382 million and 1.3 billion 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 45 and 205 million for Accotink and Pohick creeks, respectively. *Dorosoma* density was higher leading to total larval production estimates of 2.2 and 3.2 billion for Accotink and Pohick creeks, respectively. The numbers are 2-3 orders of magnitude higher than in 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. Based upon observed mean lengths, sex ratios, total larval production, and published estimates of fecundity (see Methods), the total abundance of spawning alewife was estimated to be 6021 in Pohick Creek during the period of sampling, and 2781 in Accotink creek. Based on the high densities of Dorosoma larvae found in the creeks in 2011, total gizzard shad spawning abundance during the sampling season was estimated to be 36,106 in Accotink and 53,407 in Pohick creek. 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.

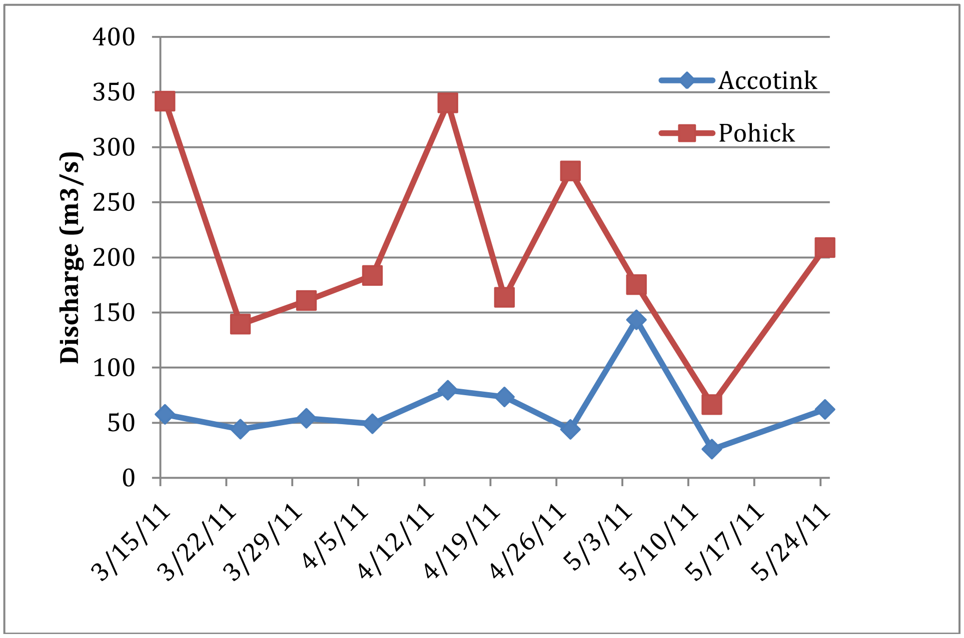

Figure 2a. Discharge rate measured in Pohick and Accotink creeks during 2011.

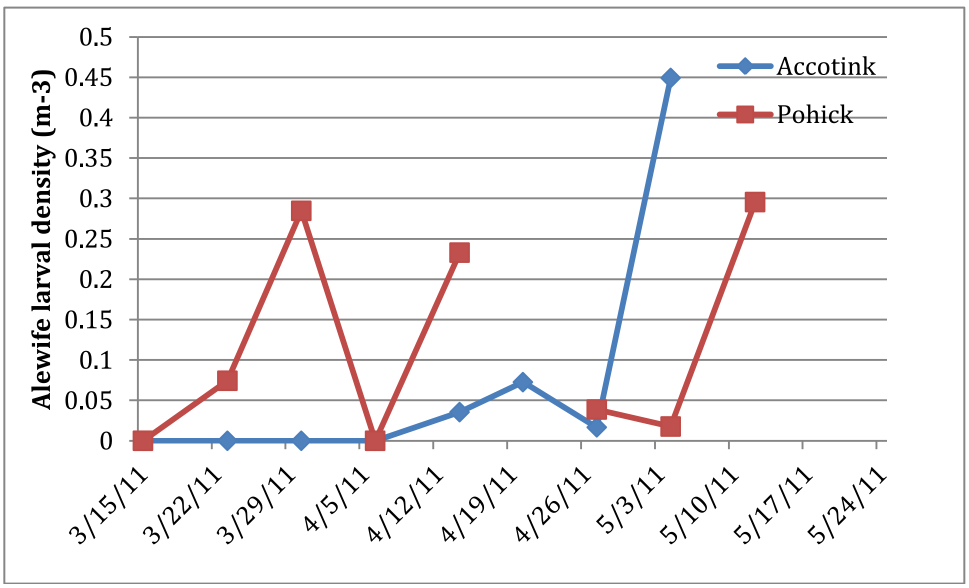

Figure 2b. Density of larval alewife observed in Pohick and Accotink creeks during 2011. Gaps indicate sampling was not possible due to adverse weather.

Table 1. Estimation of alewife and gizzard shad fecundity and spawner abundance from Accotink and Pohick creeks during spring 2011.

	Accotink Creek	Pohick Creek
Mean discharge (m^3/s)	63.2	205.8
Total discharge, 3/15 to 5/24 (m^3)	382,421,074	1,244,595,781
Alewife		
Mean density of larval *Alosa* (m^{-3})	0.118	0.165
Total larval production	45,125,687	205,358,304
Adult alewife mean standard length (mm)	231	230
Alewife fecundity	73,746	75,793
Sex ratio (proportion Female)	0.22	0.45
Number of female alewife	612	2710
Total number of spawning alewife	2,781	6,021
Gizzard shad		
Mean density of larval *Dorosoma* (m^{-3})	5.639	0.801
Total larval production	2,156,472,436	3,153,393,657
Gizzard shad mean standard length (mm)	302	300
Gizzard shad fecundity	119,454	118,089
Sex ratio (%F)	0.5	0.5
Number of female gizzard shad	18,053	26,703
Total number of gizzard shad	36,106	53,407

Discussion

With this fourth year of the new sampling protocol, some important trends are becoming apparent. 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 2011. 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. In 2008, 2009, 2010, 2011, 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 than blueback herring (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. Catches werte higher in 2011 than 2010, and especially larval density was higher than the previous year. This resulted in a much higher estimate of spawming abundance than 2010, especially for gizzard shad. In 2011, larvae were collected again in Accotink, so the absence of larvae and therefore the estimation of zero spawning abundance in 2010 was an anomaly. The number of adults utilizing Pohick and Accotink creeks typically ranges from several tens to a few thousand. Our data indicate that the spawning abundance is in the typical range with an estimate of 2781 spawning Alewife in Accotink and 6021 in Pohick. 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. The high density of gizzard shad larvae likely indicates the presence of a local population, gizzard shad is not an anadromous fish like the *Alosa* sp. To understand the contemporary importance of these systems, comparative work in other tributaries and the Potomac mainstem is needed. Finally, consistently higher numbers of alewife and gizzard shad spawners suggests that Pohick Creek provides a more productive spawning habitat. 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. 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. In addition, we do not have information from night time conditions at these sites, and larval outdrift may vary significantly on a diel cycle. 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 these potential biases in future efforts.

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 high flow because of the extensive rainfall in 2011 likely contributed to the higher 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. Comparative studies of other tidal Potomac tributaries would also help to resolve the relative importance of these creeks in the large Potomac River ecosystem. Higher sampling effort would improve the precision of larval production estimates, and a power analysis would aid in determining the number of samples needed to achieve a desired level of precision. 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). It is also important to note that the low larval densities in 2010 were a dip and not a trend, there is continued use by Alewife of Pohick as well as Accotink creek as spawning habitat in 2011. 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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