Chesapeake Bay River Herring Monitoring Plan

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River Herring Keystone Initiative
Chesapeake Bay River Herring Monitoring Plan

Rationale:

Populations of alewife *Alosa pseudoharengus* and blueback herring *Alosa aestivalis*, collectively managed as river herring, have declined dramatically since the mid 1900’s. Most of the long-term data available for assessing river herring populations in Chesapeake Bay are from fishery landings reports, but fisheries declined to low levels in the 1970’s and were closed in most states by 2012. Consequently, there is little information with which to assess the current population status of river herring in Chesapeake Bay. In some parts of the US Atlantic coast, river herring populations have been monitored using fishery-independent run counts. In Chesapeake Bay, the only available long-term run counts are from the Conowingo Dam on the Susquehanna River and Bosher’s Dam on the James River. However, too few herring pass these dams at the present time to provide useful information on bay-wide spawning runs. The purpose of this plan is to guide the development of a long-term monitoring program for river herring spawning runs in Chesapeake Bay. The proposed monitoring plan includes and builds upon existing sampling programs to provide data for assessing river herring stocks in the long term.

Monitoring strategy:

The monitoring strategy outlined in this plan was designed to provide rigorous annual river herring population data for important spawning streams and evaluate fish passage efficiency at key dams. The monitoring strategy includes four primary components.

1. **Existing long-term surveys:** Several existing long-term data sets have the potential to provide important information on changes in river herring stock status in Chesapeake Bay. These data sets include fish counts during spawning runs at Bosher’s and Conowingo Dams, juvenile and adult abundance indices, and time series of length/age structure. The primary data gaps in existing surveys are lack of rigorous run counts, poor understanding of habitat use for spawning, and lack of information on fish passage efficiency. These data gaps are addressed with the proposed new sampling efforts in components 2-4.

2. **Sentinel run counts:** Species specific run counts conducted in key spawning streams distributed regionally within the Chesapeake Bay watershed. Sentinel run counts will provide rigorous population data for regional and coast-wide stock assessments. Biological sampling will be conducted concurrently with run counts to confirm species identifications, determine length/age distribution, determine the proportion of repeat spawners, and provide genetic samples.

3. **Habitat use surveys:** Broad-scale habitat use surveys based on presence/absence data conducted in 5-25 locations per watershed for ten priority tributaries of Chesapeake Bay. Habitat use surveys will provide critical data on changes in habitat use over time,
interactions between land use and spawning activity, and potential opportunities to 
involve citizen scientists in river herring monitoring.

4. **Fish passage efficiency assessments**: Directed studies of fish passage efficiency at key 
blockages in important spawning streams. Passage efficiency assessments will provide 
critical information for evaluating and maximizing fish passage at locations where dam 
removal is unlikely.

**Existing long-term surveys:**

A number of long-term programs have collected data on river herring juveniles or adults in 
tributaries of Chesapeake Bay and are described in the River Herring Benchmark Stock 
Assessment (ASMFC 2012; Figure 1). These surveys, many of which are ongoing, will continue to 
provide a long-term perspective on river herring stock status at various sites in Chesapeake Bay. 
Relationships between these data sets and actual river herring populations are unclear. Sentinel 
stream run counts, habitat use surveys, and fish passage efficiency assessments are designed to 
fill gaps in the data provided by these existing surveys.

**Run counts at dams:**
- Bosher’s Dam fishway, James River
- Conowingo Dam fish lift, Susquehanna River

**Fishery independent indices of abundance:**
- Maryland Department of Natural Resources (DNR) Juvenile Striped Bass Survey – Head of Bay, Choptank River, Patuxent River, Nanticoke River, Potomac River
- DNR ichthyoplankton surveys – Deer Creek, Patapsco River, Mattawoman Creek (with Mattawoman Watershed Society), Piscataway Creek
- Delaware Department of Natural Resources and Environmental Control (DNREC) Haul Seine Survey – Nanticoke River
- District Department of the Environment (DDOE) Electrofishing survey – Potomac River
- DDOE Beach seine survey – Potomac River
- George Mason University Fyke net survey – Potomac River
- Virginia Department of Game and Inland Fisheries (DGIF) Electrofishing surveys – Rappahannock River, James River
- Virginia Institute of Marine Science (VIMS) Experimental anchor gill net survey – Rappahannock River
- VIMS Juvenile fish and blue crab trawl survey – Rappahannock, York and James Rivers
- VIMS Juvenile Striped Bass survey – Rappahannock, York and James Rivers

**Length and age distribution:**
- Northeast River gill net survey – DNR (length, scale age)
- Nanticoke River commercial pound and fyke nets – DNR (length, scale age)
- Potomac River fyke net - GMU (length, otolith age)
- Rappahannock River commercial pound nets – DGIF (length)
Figure 1. General locations of existing long-term data collection efforts that provide data on river herring. Note that some surveys that provide abundance indices sample many sites within a tributary but are represented here by a single symbol. Tributaries labeled are the ten priority tributaries identified below for habitat use surveys.

Sentinel stream run counts:

Rigorous monitoring of run counts is needed to track year-to-year variation in Chesapeake Bay populations of river herring. Spawning runs of anadromous fish are highly episodic events, with order of magnitude variation on time scales of several hours related to daily variation in temperature and light levels (Richkus 1974, Reynolds et al. 2007). Sampling must occur
frequently enough to capture this episodic variability or run counts will not provide accurate data on river herring populations. For river herring, salmon, and other anadromous species, hourly sampling is generally the minimum frequency at which sampling can be conducted to provide rigorous population estimates, and data gaps can introduce significant bias if peaks in migration are missed (Rideout et al. 1979, Ransom et al. 1998, Davies et al. 2007).

Available sampling methods include multibeam imaging sonar, electronic fish counters, and video or visual counts. These methods vary in cost and in the type of location where they can be employed. In systems without fish ladders or weirs that concentrate fish into a small opening, multibeam imaging sonar is likely the only option for high quality run counts. Because dam removal is currently preferred to the construction of fishways in the Chesapeake watershed, this monitoring plan focuses on conducting run counts using multibeam sonar in streams without major blockages. It should be noted that abundance indices generated from weekly gill net, fyke net, electrofishing, or other similar methods are likely much less rigorous because of challenges in accounting for the effects of spatial and temporal variability, gear selectivity, and gear efficiency. Although no method is perfect, it is our strong opinion that conducting run counts will provide the most rigorous data for assessing river herring populations.

The sentinel run count locations listed below provide wide geographic coverage of key spawning streams that should provide effective data for assessing trends in Chesapeake Bay river herring populations. These locations are each known to have river herring spawning runs, are of management interest, and either are, or have tributaries that are, suitable for multi-beam sonar run counts. Multi-beam sonar is limited by the distance over which high resolution imaging is possible, among other factors. A list of site characteristics follows which details optimal conditions for multi-beam sonar run counts. For large rivers, the best option is likely to choose a representative tributary in which run counts can be conducted. Alternatively, Hughes and Hightower (2015) estimated run counts of river herring in the relatively large Roanoke River, North Carolina using a combination of split-beam and multi-beam sonars. The primary drawback of this method was that it required substantially more staff time (five vs. one day each week) than for smaller streams.

Potential Locations for sentinel stream run counts and relevant management jurisdictions (sites indicated as stars on map in Figure 2):

- Lower Susquehanna River – DNR (Deer Creek or Northeast River)
- Choptank River – DNR
- Nanticoke River – DNR and DNREC
- Patapsco River – DNR
- Potomac River – Potomac River Fisheries Commission, DNR, DGIF, DDOE (Mattawoman Creek, Pohick Creek or other)
- Rappahannock River - DGIF
- York River - DGIF
- Lower James River - DGIF
Site characteristics ideal for multi-beam imaging sonar:

- Stream width <12 m – streams can be narrowed to this width using fences/weirs
- Stream depth < 3 m with a sloping or rounded bottom that is free of obstructions such as downed trees or large rocks
- Relatively laminar flow – no major eddies, strong turbulence, or strong tidal influence
- Access to power – sufficient power can be provided using solar if necessary
- Accessible for biological sampling – electrofishing or fyke netting will need to be conducted at least weekly to determine changes in species composition during the spawning season
- Security – a computer and other electronic equipment need to be housed on site and protected from theft, precipitation, and flooding
- Relatively few gizzard shad, which are most likely to be both highly abundant and confused with river herring in sonar images.

Implementation cost estimate:

The following estimated costs are provided here and in subsequent sections to assist with planning for the costs for monitoring. They are not intended to represent grant or contract budgets and thus do not include salaries, benefits, indirect costs, or other costs that may be associated with conducting monitoring.

- ARIS multibeam sonar - $80,000-$100,000 per unit including cables, mounting hardware, and other supplies – cost variability in this category is primarily due to optional automated pan/tilt control mechanisms
- Biological sampling - $1,000 per site per year for maintenance of existing equipment and supplies. Management jurisdictions and many academic institutions already possess equipment for biological sampling (electrofishing, fyke nets, etc.). This cost item assumes that existing equipment will be used for sampling.
- Staff time – As a rough estimate, approximately seven months of staff time will be required to collect and analyze multibeam sonar and biological data for each site. Cost will vary by jurisdiction.

Implementation timeline:

The suggested target date for full implementation of the sentinel run counts is 1 February 2016. Implementation by this date would allow for the collection of 10 years of monitoring data prior to the end of the current Chesapeake Bay Watershed Agreement in 2025. Run count monitoring would provide an increasing level of data as the monitoring program progresses through time. Examples of data are:

- Year 1 – First estimate of run size, age distribution of run
- Year 5 – Direction of run size trend (increasing, decreasing or no trend), variability in age distribution, trend in size at age
- Year 10 – Inter-annual variability in run size, responses to conservation actions, early indication of spawner-recruit relationship, total mortality rate, trend and variability in age distribution and size at age
Figure 2. Priority Chesapeake Bay watersheds for habitat use surveys (labeled and colored watersheds) and potential sentinel spawning run count sites (stars). Inset shows sampling sites for 2014 habitat use pilot study in the Choptank River watershed.

Habitat use surveys:

River herring spawning runs are widely distributed in both large and small streams throughout much of the Chesapeake Bay watershed (e.g. O’Dell et al. 1975, Klauda et al. 1991). In most Chesapeake tributaries, surveys of habitat use during spawning runs have not been conducted in recent decades. This critical data gap can be filled by monitoring spawner presence/absence...
at multiple sites within important watersheds. Ten priority watersheds for spawning habitat use surveys were identified (Figure 2). These watersheds were identified based on tributary size, presence of known spawning runs and streams of particular interest to management jurisdictions. Within each watershed, we anticipate that 5-25 sites will need to be monitored, depending on watershed size, to understand the distribution of spawning. The Choptank River map inset provides an example distribution of habitat use sampling sites from a spring 2014 habitat use pilot study conducted by SERC.

We are currently testing two methods for determining presence/absence that take advantage of genetic techniques to minimizing costs while maintaining accurate species identifications. We anticipate that environmental DNA (eDNA) analysis of water samples will be the least expensive method for monitoring presence/absence on a large scale. We are testing eDNA sampling, which only requires collection of a water sample, and ichthyoplankton sampling, as two potential methods for conducting habitat use surveys in collaboration with citizen scientists. Ichthyoplankton sampling is an effective method for identifying spawning habitat, but can require substantial sample processing time (Harris and Hightower 2010). For eDNA samples, we are working with Dr. Louis Plough and a graduate student at the University of Maryland Center of Environmental Science Horn Point Laboratory to develop and test a PCR-based detection method. We anticipate that method development will be completed in early fall 2015 and testing of samples collected in spring 2015 habitat use surveys will be completed by January 2016.

In recent years, Maryland DNR has conducted anadromous fish ichthyoplankton surveys in tributaries to the Potomac River (Piscataway Creek and Mattawoman Creek), lower Deer Creek, and lower Patapsco River. Virginia DGIF has also conducted electrofishing in several locations to determine herring presence/absence. To expand these limited efforts to the spatial scale envisioned for habitat use surveys, SERC conducted baseline habitat use surveys in spring 2015 in the Choptank River, Deer Creek, Patapsco River, Potomac River (with several collaborators), Rappahannock River, and Pamunkey River (the major tributary of the York River) (see above map for locations). In rivers where management jurisdictions were already conducting some sampling, the SERC survey expanded sampling to a much broader range of sites throughout these watersheds. Among the ten priority watersheds, baseline habitat use sampling has not yet been conducted in the Nanticoke, Northeast, Patuxent and James Rivers.

**Implementation cost estimate:**

- Sample collection - $500 for sampling equipment in each watershed. Sample collection costs may be lower if eDNA sampling is used.
- Genetic analyses - $20 per sample including supplies, labor, and analyses

**Implementation timeline:**

The suggested target date for full implementation of the habitat use surveys is 1 February 2016. Implementation by this date would allow for the collection of 10 years of monitoring data prior
to the end of the current Chesapeake Bay Watershed Agreement in 2025. Ten years of data would provide increasing levels of information with time. Examples of data are:

- Year 1 – Species-specific spawner distribution and habitat use
- Year 5 – Trend in habitat use (increasing, decreasing or no trend)
- Year 10 – Inter-annual variability in habitat use, responses to management actions (e.g. dam removal), relationships with environmental variables (e.g. rainfall)

**Fish passage efficiency assessments:**

For dams that are unlikely to be removed in the near term, ensuring adequate fish passage is an important component of monitoring river herring populations. Fish passage monitoring should include rates of both upstream and downstream passage of adult spawners, as well as downstream passage of larvae and juveniles. Assessments should include 1) the abundance of fish approaching the dam, 2) the proportion of fish entering and exiting passage structures unharmed, 3) the minimum, maximum and mean time of successful passage, 4) the minimum, maximum and mean number of attempts prior to successful passage, and 5) the extent to which fish make use of spawning habitat above the dam. Downstream passage and survival, although more challenging to quantify due to the smaller size of fish, is critical to evaluating whether fishways are an effective option for provide river herring with access to habitat above dams.

**Implementation cost estimates:**

- PIT tag readers (multiplex) - $4,000 each including antennas and other supplies – This is the minimum required for each fishway that is monitored. It may be preferable to have two readers for most fishways.
- Tags $2-$3 each depending on the number ordered.

**Implementation timeline:**

The initiation of fish passage efficiency assessments could begin as early as 1 March 2016, provided funds become available with sufficient time to purchase and deploy telemetry equipment. Fish passage efficiency assessments will provide information along the following timeline:

- Year 1 – First estimates of passage efficiency, species specific differences
- Year 5 – Trends in passage efficiency, proportion of repeat spawners, initial responses to improvements to fish passage structure (if changes made)
- Year 10 – Inter-annual variability in passage efficiency, stability of improvements to fish passage structure, variability and trends in the proportion of return spawners

**Patapsco River Dam Removal – An Opportunity for Integrated Monitoring**

The anticipated removal of Bloede Dam on the Patapsco River in Maryland represents a unique opportunity to document the benefits of a mainstem dam removal for river herring using an integrated monitoring program. The combination of multi-beam sonar run counts, telemetry of
PIT tagged individuals, and habitat use surveys would generate an unprecedented dataset for evaluating the effectiveness of dam removal for restoring river herring populations. Combining run counts with PIT tagging provides both run size and the proportion of the run which uses each segment of the river monitored with a PIT antenna. PIT telemetry can also provide estimates of within-river spawning mortality, relationships between migration and river flow, and the annual return rate of tagged fish (Raabe et al. 2014). An integrated monitoring program for river herring would provide the best data if implemented during the first spawning run following dam removal. Data are not needed prior to dam removal as river herring are not thought to use the existing fish ladder.
Estimated costs per river monitored

The following budget table provides a summary of potential monitoring costs per river, assuming the installation of one multi-beam sonar station for run counts and one fishway where passage efficiency is monitored. Costs are separated for equipment (Year 1 only) and annual monitoring. Note that staff time is calculated for primary project participant only. Some aspects such as electrofishing for biological samples and pit tagging may require additional staff on field days and assumes the use of existing equipment for biological sampling.

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<th>Equipment and initial supplies</th>
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<td>Multi-beam sonar</td>
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<td>Computer, mounting hardware,</td>
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<td>other sonar supplies</td>
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<tr>
<td>Multiplex PIT tag reader,</td>
<td>$4,000</td>
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<td>antennas, and supplies</td>
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<tr>
<td>Total</td>
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<table>
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<th>Annual monitoring costs</th>
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<tr>
<td>Biological sampling equipment</td>
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<td>maintenance and supplies</td>
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<tr>
<td>eDNA or ichthyoplankton sample collection</td>
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<td>eDNA or ichthyoplankton genetic analyses</td>
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<td>PIT tags</td>
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<table>
<thead>
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<th>Staff time</th>
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<td>run and analysis of multi-beam</td>
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<td>sonar data</td>
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<tr>
<td>Biological sample processing</td>
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<td>(dissection, otolith/scale</td>
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<td>aging)</td>
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<tr>
<td>eDNA sample collection and</td>
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<td>preparation for sequencing</td>
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<td>PIT tagging and data analysis</td>
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<td>Total</td>
<td>9.5 months</td>
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References:


Klauda, R.J., Fischer, S.A., Hall, Jr., L.W., Sullivan, J.A. Alewife and Blueback Herring Alosa pseudoharengus and Alosa aestivalis. Maryland Department of Natural Resources. 29 pp.


