

# Atlantic States Marine Fisheries Commission

## *Report on the River Herring Data Collection Standardization Workshop*



March 2016



*Vision: Sustainably Managing Atlantic Coastal Fisheries*

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## Summary

Discrepancies among river herring monitoring programs along the Atlantic coast, both in design and data being collected, identified by the ASMFC's River Herring Technical Committee and NOAA Fisheries' and ASMFC's River Herring Technical Expert Working Group were grounds for recommending and convening a meeting on data collection and standardization. Goals and objectives for the workshop were:

- 1) Review long-term State, Federal, and Tribal Survey river herring fishery-independent monitoring programs, and acknowledge fishery-dependent data programs, in the U.S. and Canada. This includes survey design and biological sampling.
- 2) Discuss standardized approaches to data collection, and identify what can be implemented quickly with minimal changes to current sampling programs. Identify long-term needs as time permits, including challenges (e.g., resources).
- 3) Consider information needed for data limited stock assessment approaches.
- 4) Produce a meeting summary to help improve river herring data collection throughout the range of river herring and help inform future monitoring efforts (e.g., stock assessment).

The focus of this workshop was fishery-independent surveys and monitoring programs, but some topics discussed (i.e., biological sampling) were relevant to fishery-independent and fishery-dependent programs. Agency representatives presented all fishery-independent and fishery-dependent programs that sample the river herring species (Blueback Herring, Alewife, and hybrids of these two species). Starting the workshop with presentations by agency representatives as well as compiling monitoring program information prior to the meeting was done to identify differences between existing programs and to focus on aspects that need to be standardized. The details of each agency's monitoring programs, contact person, and contact information are provided in appendices A-S. Standardization discussions first focused on design by survey type followed by biological sampling, as the latter is relevant to all survey types. Considerations and recommendations based on discussions during the workshop are provided in this summary. It was discussed throughout the meeting that implementing modifications to existing monitoring programs or developing new monitoring programs based on the meeting recommendations will be dependent on available resources which vary across agencies. However, some recommendations should be achievable across monitoring programs with minimal additional resources and time. Participants identified these recommendations to be addressed in the short term to improve standardization. Other recommendations were identified as likely needing significant additional resources and/or time to be addressed.

This summary serves as general guidance, acknowledging that design of new monitoring programs or modification of existing monitoring programs will be highly dependent on the site location and available resources. Site-specific guidance should be sought from experienced monitoring program representatives that have implemented programs in sites similar to the sites where programs are to be modified or developed. In addition to the recommendations in this summary, the workshop served as a

forum for river herring monitoring program representatives to share information and lessons learned. Public comment was solicited throughout the workshop. The workshop agenda is in Appendix U.

## **Fishery-Independent Survey Design**

The primary consideration when designing and implementing a river herring survey is to determine the objective. Is the objective to get a total abundance estimate, or to get a relative index of abundance? Traditional fishery-independent surveys (e.g., trawl surveys) are typically used to estimate relative abundance indices and run counts are typically used to census total abundance or sample abundance to estimate total abundance. The target precision of abundance estimates is another consideration to be addressed with the survey design, if the survey is not a census (total count).

Timing, location, and gear used for the survey are also major considerations when monitoring river herring and will depend on the primary objective of the survey. If the objective is to census or estimate total abundance, run counts on rivers or streams where all fish pass a common point are typically used during spring spawning runs. If the objective is to estimate relative abundance, surveys may be conducted during different seasons and may occur in more open systems (i.e., estuaries or the ocean). Different survey gears may be more appropriate for certain waterbodies and survey objectives. A common issue across surveys operating during the spawning season is the potential for gear saturation<sup>1</sup>. Measures should be taken to avoid saturation when designing and implementing the survey. As techniques and science evolves, survey design changes may occur to address this evolution. Any time a survey design is changed, it can affect abundance estimates over time and these changes may need to be addressed during data analysis. When possible, conducting a side by side comparison of the survey with and without changes is a good practice for determining conversion factors.

### *Recommendations*

- A pilot study should be conducted to identify the best location and protocol, given the objectives of the survey and the target precision of survey estimates. (Long term, significant resources<sup>2</sup>)
- Document all changes to survey design and always provide a history of changes with data. (Short term, minimal resources)

### **Run Counts**

When a run count is located on a fishway or fish passage area and the passage is controlled (e.g., a manually operated fish lift), a total passage count is possible. If a run count is to be located at a barrier (e.g., dam, fishway) on the river, there is the need for plans to maintain the time series of the run count

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<sup>1</sup> Gear saturation occurs when the probability of capture of more individuals by a gear is restricted by the numbers of individuals already captured by the gear (Caddy 1998).

<sup>2</sup> Noted that a pilot study could be conducted in 1-2 year period but that financial resources may be impediment to being a short term recommendation.

in the case of barrier removal in the future. When a run count is located on a fishway or fish passage area and the passage is unrestricted (e.g., an open fish ladder), a statistical sampling design is best.

Another location consideration for run counts is where the run count occurs relative to where the majority of the spawning occurs in the river. Monitoring a tributary of a river main stem may be appropriate if a distinct population is imprinted to this tributary and determining abundance of this population is the objective of the survey. If the population spawns in other tributaries and/or in the main stem, it may be more appropriate to conduct the run count where these other spawning fish can be counted.

Other key considerations are the desired scale of abundance estimates (daily or annual) and the diel timing of statistical sampling. For diel timing of sampling, it is important to determine if counts during a certain time frame of a 24 hour period (e.g., dawn) are representative of counts during other time frames (e.g., night). If migration varies throughout a 24 hour period, consider allocating sampling to different time frames (i.e., strata) across the 24 hour period to account for the variation due to diel migratory behavior. This will improve the precision of total count estimates.

A potential bias for run counts is milling, or fish passing a counting site and then falling back downstream past the counting site. These fish may pass upstream at the counting site again and/or be counted as they fall back, leading to double counts. Efforts should be made to prevent (i.e., a weir) or quantify double counts during counting.

These considerations and additional considerations for designing or modifying river herring run count surveys are outlined in a decision tree in appendix V.

### *Recommendations*

- Provide the location of the run count relative to the majority of spawning on the waterbody in survey meta-data. (Short term, minimal resources)
- Statistical designs for run counts should be based on Nelson 2006, Rideout 1979, Davies et al. 2007, and/or McCormick et al. 2015. Stratify sampling within a day if diel migration varies. (Long term, significant resources)
- If volunteers will be used for run counts, develop a standardized training program. (Long term, significant resources)
  - Validate volunteer counts. Consider using a post-passage trap (e.g., weir), biologist counts, or video counts to validate volunteer counts and species identification. (Short term, significant resources)
- Consider factors that may impact fish passage (Castro-Santos et al. 2009) and conduct efficiency studies of river herring passage (Franklin et al. 2012) at the structure/barrier.

### ***Visual Run Counts***

Visual run counts are best for sites where the target species is the dominant species or when appropriate frequency of species composition sampling can be conducted. Visual counts should only be conducted



at fishways or narrow passageways (e.g., natural bottleneck, weir) in clear, shallow water where all fish pass through a visible point. Boards and other visual aids (e.g., polarized sunglasses) can be used to provide contrast to dark bottoms.

Visual counts can be very labor-intensive and can be inaccurate particularly when large runs of fish occur, but these counts can provide real time feedback on run abundance and demographics to help in determining an appropriate sample size for biological sampling.

### ***Electronic Run Counts***

Electronic run counts are best for sites where the target species is the only species or when appropriate frequency of species composition sampling can be conducted. Electronic counts should only be conducted at fishways or passageways (e.g., natural bottleneck, weir) where all fish pass the counter. Electronic counters should not be used at a site where air entrainment and turbid water can cause false positive counts, but can be used at sites with water visibility not suitable for visual or video counts.

Counting tunnels should be sized such that they are large enough to pass all targeted species. Generally, the diameter of the tunnels should be equal to half the length of the target species. The number of counting tunnels should also be considered, given the run size, to prevent delayed passage. Electronic counters require a power source and can be labor-intensive (daily maintenance checks). The power demands of the counter vary depending on the setup and include battery, solar, or AC/DC power. Debris nets should be considered to help keep debris from being counted. Electronic counters have a variable conductivity range for which they operate and, as part of site selection, conductivity measurements should be collected (not appropriate at sites with brackish water). If the counter blocks downstream emigration, remove the counter. If emigration overlaps with immigration, consider alternative count methods.

#### *Recommendations*

- Electronic counts should be validated. Consider post-passage traps (e.g., weir), biologist counts, or video counts. (Short term, significant resources)
- Tubes should be checked for any debris on a daily basis.

### ***Video Run Counts***

Video run counts should only be implemented at fishways or passageways (e.g., natural bottleneck, weir) where all targeted species pass in front of the camera and visibility is adequate. Retroreflective backdrops can be used to improve visibility. Infrared cameras and lighting may be best to reduce impact on River Herring behavior.<sup>3</sup> Video counts may be the best option for sites with multiple species passing and/or for counts of individuals too large to pass electronic counter tubes. A power source is required

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<sup>3</sup> This was note das possibly impacting river herring behavior due to the use of light or need to increase water visibility with traditional camera lenses

for this type of survey. The power demands of the counter vary depending on the setup and include battery, solar, or AC/DC power. Video counts can help validate counts using other methods and can also help with creating outreach materials (e.g., online videos) for the general public. Video counts can be time and data intensive. Identifying positive frames, frames with video of organisms passing the camera, can significantly reduce processing time. Software is available for this purpose in standalone (e.g., Salmonsoft), proprietary (e.g., Mobotix camera control software) and open source (e.g., iSpyconnect) forms. Sampling video frames with a statistical design may be more feasible than a census. Sampling methods should follow the same protocols as those commonly used for visual counts.

### ***Hydroacoustic Run Counts***

There has been limited application of river herring run counts using hydroacoustic equipment along the eastern U.S. coast. Hydroacoustic equipment such as split-beam sonar- where a 'fish track' from echoes correlated temporally and spatial in a fixed location can represent fish and schooling fish assemblages (Hughes and Hightower 2015)- can be utilized when river herring are primary the species encountered. Multibeam sonar hydroacoustic systems such as Dual Frequency Identification Sonar (DIDSON) – which utilizes a larger beam width and provides clearer visual interpretation of images- can be more useful for monitoring areas with multiple alosine species of comparable length (Grote et al. 2014). Monitoring sites with poor visibility (blackwater rivers) and/or high turbidity may be most suitable for these types of counts. Hydroacoustic counts are best for sites where the target species is the only species or when appropriate frequency of species composition sampling can be conducted. DIDSON output is essentially video quality sonar and provides the ability to differentiate species groups. DIDSON is best for fine-scale measurements on smaller rivers. Split-beam sonar is more suitable for large river systems, but provides less detailed data and is not suitable in rivers with high species diversity. There are software packages available to derive counts from sonar data. These methods can be costly and labor intensive.

Two potential biases with hydroacoustic methods are saturation (e.g., high densities of fish) and shadow effect (e.g. shadow cast from fish obscure other schooling fish). Milling and double counts are also more likely with sonar because fish are not being forced through a bottleneck, creating a greater chance for moving back and forth across the beams. With these considerations in mind, site selection is very important.

### ***Other Run Count***

There has been some experimental survey work done with analysis of environmental DNA (eDNA). This type of survey has primarily been used for presence/absence studies. There is the potential to use this method to estimate density and abundance, but there were no defined protocols or methods discussed at the meeting.

## **Traditional Fishery-Independent Surveys**

Traditional fishery-independent surveys are typically used to estimate relative abundance indices and some of these surveys may be useful for indexing juvenile fish that are not encountered in run counts. Some of the existing surveys covered at the meeting are multispecies surveys that happen to encounter river herring. As with targeted surveys, there is the potential for confounding variables that affect the catchability of encountered species and these variables should be considered when designing surveys. It is recognized that implementing some recommendations specifically for river herring in multispecies surveys may not be feasible, but some should require minimal change and/or additional effort.

The following are general guidelines that could be used to identify candidate indices of relative abundance in a stock assessment that were discussed to focus on potential survey modifications:

- Time series: generally at least 7-10 years of data
- Survey design: a randomized statistical design is preferred, though fixed station surveys are utilized if the same sites are used over time and catch at stations remains persistent relative to catch at other stations (Warren 1994)
- Sampling timing/coverage: surveys should be conducted at appropriate times to encounter river herring in the location being sampled and should reflect abundance of the unit being assessed (e.g., distinct river population or multiple mixed populations aggregating in a location)
- Consistency in survey methodology: consistent survey designs are preferred, but methodology changes made to improve the survey don't prevent the survey from being used in assessments (changes should be clearly documented and communicated with data)

### *Recommendations*

- Record all abiotic variables that may affect catchability of river herring (e.g., environmental data, gear performance, etc.). (Short term, minimal resources)

## ***Electrofishing***

Electrofishing surveys may be the best option when discard mortality should be minimized (i.e., highly depleted populations) and/or in habitats where other gear types are not effective. Most electrofishing surveys covered at the meeting are targeting river herring. Gear saturation may be an issue when sampling high densities.

### *Recommendations*

- Record all variables that may affect catchability. Some unique to electrofishing discussed at the workshop are equipment settings such as watts (Amps x Voltage), conductivity, frequency, number of netters, and effectiveness of netters. (Short term, minimal resources)
- Electrofishing should be done at sites where fish are likely to linger.

## ***Seines***

Existing seine surveys discussed during the meeting primarily target YOY and adult herring, but also encounter juveniles (see NY seine survey in appendix H). These existing surveys use fixed sites, as accessible and “seineable” sites can be limited.

Other considerations are as follows:

- Lead line must be on the bottom and floats must be at the surface to get a good sample. Too much submerged aquatic vegetation (SAV) can cause the lead line to roll and gear not to perform well, so bottom habitat can play a big role in site eligibility. Also, depth of the site should be considered both at high and low tide to help determine if a site is eligible.
- Standard to sample with the tide, except when a strong wind is opposing the tide, which can cause the seine to invert.
- Existing surveys have 30 minute minimum between repeat samples at the same site.
- Having experienced seiners that know the appropriate pace and how to handle snags is preferable.
- Standardizing the gear: mesh size, type of material, etc. is important for surveys to be truly comparable.

## ***Gillnets***

Size selectivity is an important consideration when selecting mesh size for this type of surveys. Drift gillnets and fixed gillnets are currently utilized in surveys and the appropriate type will be site-specific. Driftnets should be set hanging loose. Many of the state gillnet survey programs use monofilament with varying test/diameter dimensions. It was noted by a number of attendees that when calculating CPUE from gill nets, selectivity corrections should be made using the Millar and Holst (1997) method of calculating selectivity curves. State programs using gillnet surveys also varied in being fixed sites or random stratified site selection.

### ***Recommendations***

- Gill nets should be set during a time when activity is expected to peak for the target species.
- Setting time should not be so long that fish will degrade or be compromised by predators.
- If utilizing randomization for site selection, you should also randomize depth strata where possible.

## ***Trawls***

Many trawl surveys covered at the meeting are multispecies surveys that encounter river herring. These surveys are likely encountering mixed populations of river herring and can be useful for mixed stock

indices of abundance of juvenile and adult river herring, and biological sampling. Some of these surveys are also long time series using consistent survey designs.

### ***Push Nets***

Push net gears are used in several existing surveys and were identified as effective gears for sampling river herring at some sites. Sampling by these surveys is primarily conducted at night<sup>4</sup>.

### **Tagging Studies**

There are multiple types of tags being used in river herring studies and monitoring programs including radio tags, acoustic tags, Passive Integrated Transponder (PIT) tags, and conventional physical tags (e.g., streamer tags).

Powered tags (acoustic and radio) are capable of greater than 1 year battery life. These tags are typically gastrically implanted, but limited experiences with surgical implantation in Blueback Herring and shad suggest adequate post-surgery survival. Radio tags are limited to freshwater studies only. Acoustic tags are applicable in freshwater, estuarine, and marine environments. LOTEK makes dual tags, but they are not supported by Vemco, which manufactures most acoustic monitoring technology (issues with duplicate codes from Lotek tags). These tags can be used for habitat use, movement rate, migration rate, coastal movement/migration, and fish passage studies.

PIT tags are energized by antennas so the tag (and fish) must pass through a relatively constrained area (small enough to support a properly functioning antenna). Tagged fish are detected with receivers. Receivers have to be deployed at specific areas to monitor movement. These tags are commonly used for fishway/passage efficiency studies and could also be used for movement/habitat use in smaller streams/rivers, mortality studies, and spawning site fidelity studies. PIT tags are susceptible to interference from metals, including rebar embedded in concrete.

Passive conventional physical tags must be recaptured and reported. These tags could be used for many of the same objectives of PIT tags.

### ***Recommendations***

- Consider double tagging fish with external and internal tags to aid in recapture rate. (Long term, significant resources)
- It is recommended that any researcher conducting an acoustic study become members of the Atlantic Coastal Telemetry Network. (Short term, minimal resources)

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<sup>4</sup> Push nets have also been used by Canada DFO to sample river herring larvae. This data has been used to help calibrate the relative index of abundance.

## **Biological Sampling**

Shifting the meeting focus to biological sampling, the group covered topics necessary to understand the biological characteristics of the monitored river herring and to improve population dynamics studies and assessments. The biological sampling recommendations were discussed in context of fishery-independent and fishery-dependent monitoring and how they apply to both types of monitoring programs.

### **Biological Sampling Design**

- Biological sampling should be conducted proportional to the abundance metric (catch, run counts, etc.) to achieve desired precision of biological parameters. Sampling may need to be adjusted to capture demographic changes (e.g., changes in age composition during the run). Real time monitoring is recommended to identify abundance and demographic changes. (Long term, significant resources)
- If ages are collected in a binned design, consider sample size requirements for age-length keys from Coggins et al. (2013). (Short term, minimal resources)

### **Population Identification**

- Population identification indicators should be collected routinely in all fishery-independent and fishery-dependent sampling. Methods include genetics (preferred- seek expert advice), recaptures of tagged fish, scale morphology, and otolith microchemistry (two otoliths needed for analysis - seek expert advice). (Short term, significant resources)

### ***Genetic Samples***

- Genetic samples are the preferred population identification indicator to be collected from all fishery-independent and fishery-dependent sampling. River sampling is necessary for population baseline samples and ocean sampling is necessary for mixed stock analysis. Fin clips are the preferred tissue sample to collect. Eric Palkovacs has provided a protocol for extraction and preservation of tissue samples that should be adopted (appendix T). (Short term, significant resources)
- A central location on the Atlantic coast for sample storage with appropriate conditions for archiving genetic samples should be utilized. All data (weight, length, sex, location, age, etc.) should be maintained and provided with the archived tissue sample. Genetic samples can also be useful for species identification and age determination if hatchery information can be provided. (Long term, significant resources)
- Mixed stock sampling (ocean incidental catch, ocean fishery-independent surveys) should be done annually.

- Consult with Dan Hasselman and Eric Palkovacs for guidance on frequency and life history stage to target for population baseline samples (river sampling). (Long term, significant resources)

### **Species Identification**

- Species identification (including river herring hybrids) needs to be done routinely in all fishery-independent and fishery-dependent sampling. All river herring collected, including suspected hybrids, should be identified as either Blueback Herring or Alewives and potential hybridization should be noted with the species identification when suspected. A suspected hybrid should be assigned to the species that it most closely resembles. Species identification is considered a high priority to enable moving from aggregated river herring population estimates to species-specific population estimates and conservation. (Short term, minimal resources)
- Methods to identify river herring species include visual field identification (field), examining scale morphology (lab), genetics (lab), and examining the peritoneal cavity color (lab). Field identification should be validated, when possible, with a more rigorous laboratory-based method. (Short term, significant resources)
- More research is needed to determine the best methodology for identifying species and this methodology should be adopted by all agencies when determined. (Long term, significant resources)
- In the interim before the best method is determined, record the method(s) for species identification, including any method to identify hybrids, and provide with data. (Short term, minimal resources)

### **Length**

- Lengths should be recorded in all fishery-independent and fishery-dependent sampling. There is the potential for confusion when measuring total length (i.e., maximum or natural) and these two types should be differentiated and noted when recording length data. Multiple length types should be recorded when possible to develop length conversions. (Short term, minimal resources)

### **Weight**

- Individual weights should be collected, particularly when all individuals captured are not counted. Individual weights are useful for developing morphological relationships and for characterizing compositions of total catches recorded in weight. (Short term, minimal resources)
- Spawning condition should be collected from fish along with individual weight when the fish are collected during spawning. (Short term, minimal resources)

### **Age Structure**

- Recommendations made at the ASMFC River Herring Ageing Workshop should be adopted. Some of these recommendations discussed in detail again at this meeting included:
  - Paired otolith and scale samples should be collected from all fish sacrificed for biological sampling. Otoliths should be collected for age determination and microchemistry analysis. Scales should be collected for age determination and spawner mark counts. (Short term, minimal resources)
  - All labs ageing river herring should adopt a standardized protocol (i.e., MA DMF protocol; Elzey et al. 2015). (Short term, minimal resources)
  - Precision statistics should be included with age data. (Short term, minimal resources)
  - Age validation studies should be conducted for all age structures using known-age fish. (Long term, significant resources)

### **Sex**

- Sex should be recorded from all fishery-independent and fishery-dependent sampling. The two techniques typically used are field identification and lab dissection for gonad examination (higher accuracy). Field identification should be utilized if the fish is not sacrificed, otherwise lab dissection is recommended. (Short term, minimal resources)

### **Maturity**

- Maturity (immature or mature) should be recorded when sampling mixed life stages of river herring. This will primarily pertain to ocean sampling. Determining maturity from ocean sampling, unless early in spring when fish are ripe, is very difficult, as mature fish are resting at other times.

### **Spawning Condition**

- Spawning condition should be recorded when sampling spring spawning runs. Recommended categories for characterizing spawning condition are gravid, running, and spent. (Short term, significant resources)

### **Sample Storage**

- Fish to be analyzed for OTC marks need to be wrapped in tin foil and refrigerated to avoid degradation. (Short term, minimal resources)



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## Appendix A. Surveys by Gear Type and Agency Contact Information

- **Runs Counts**

- Visual Run Counts

*River*

Canada

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- Electronic Run Counts

*River*

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○ Hydroacoustic Run Counts

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● **Electrofishing**

*River*

○ Boat Electrofishing

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○ Backpack Unit Electrofishing

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- **Seines**

- Beach Seine

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- Haul Seine

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- **Gillnets**

*River*

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- **Trawls**

*Ocean/Marine*

Canada

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- **Push Nets**

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## Appendix B. Canada Department of Fisheries and Oceans River Herring Monitoring Programs (Dr. Jamie Gibson & Dr. Cindy Breau)

Data fall broadly into two categories: counts at fishways and dams, and marine trawl surveys. DFO Maritimes Region (the region from the Maine – New Brunswick border to the northern tip of Cape Breton Island, Nova Scotia) is working on developing assessment methodologies for the many rivers and fisheries for river herring. Data compilation and evaluation from older programs, selection of populations for monitoring, frequency of assessments and assessment methods are largely under development. With the exception of the Gaspereau River alewife stock, the last assessment was published in 2001 (using data to 2000).

### Counts at Fishways and Dams

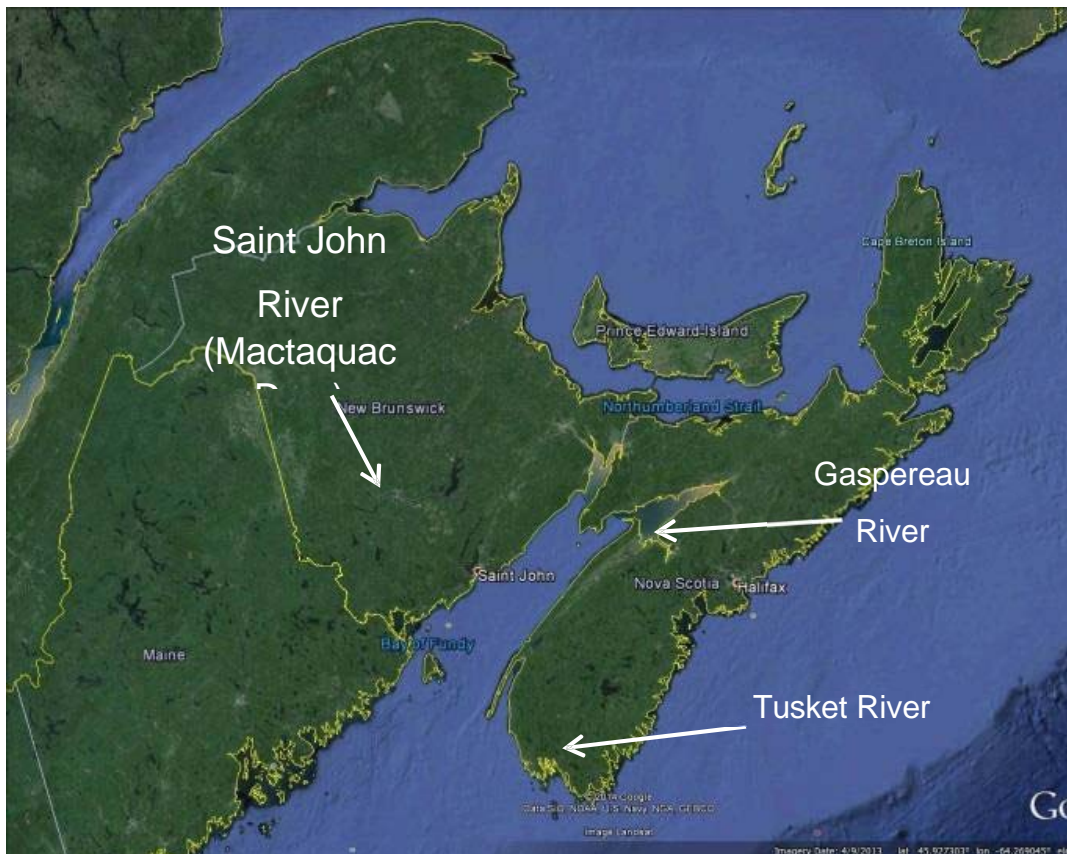


Figure 1. Locations of river herring counting facilities.

### **Gaspereau River Fishway Counts**

River herring are fished commercially in-river in the Gaspereau River. All fisheries operate downstream of the White Rock Generating Station (the generating station is the furthest downstream of the five generating stations on this river). Only alewife are encountered. Counts and biological sampling occurs as fish ascend the fish ladder at the White Rock dam. Counts are considered indicative of spawning escapement because they occur upstream of the fishery. Counts and sampling do not occur in all years.

### ***Survey methods***

Counts at the fishway are available for the years 1983-1985; 1997-2006; and 2015. For the years 2001 and earlier, counts are recorded as the number of alewife ascending the fishway in 15 minute blocks, typically from 0800h to 2000h daily, although both the time block and the daily period varied somewhat depending on the number of fish ascending the ladder on a given day.

The ladder was blocked just below the counting facility when counts were not occurring, and the count is considered a total count for this reason. From 2002 to present, monitoring has occurred via video monitoring, and an escapement estimate has been obtained via a stratified random count from the video. A one-way design was used prior to 2015 (15 minute blocks), and a two-way design (5 minute blocks) was implemented in 2015.

For the years when counts occurred during the 1983-2001 time period, sampling for biological characteristics (species, sex, fork length, weight, and a scale sample) was done by sampling 10 fish of every 1,000 fish that ascended the fish ladder. Roughly 500 scales were then randomly selected from the resulting samples and used to determine the ages and previous spawning history. Some sampling for biological characteristics has occurred since 2002, although sampling was not randomly distributed over the run and the representativeness of these samples is unknown.

### ***Sampling Intensity***

Counts and video monitoring take place from the start of the run in late April to the end of the run in late June. Biological sampling also covered the entire run. The video camera has been operating each year, but the video is not counted every year.

### ***Biases***

The biological sampling (1983-2001) is considered representative of those fish escaping the fishery but might not be representative of the entire run because the fishing season is closed after May 31st. The counts are not thought to be biased, but in some years there can be issues with the video camera. In those years, the counts are considered partial and are reported as minimum estimates of the escapement. Fishway efficiency may not be 100%. Assessments for this stock, during which data are compiled and evaluated, have not taken place since 2007 (data to 2006).



### **Tusket River Fishway Counts**

River herring are fished commercially in-river in the Tusket River and in its estuary. All fisheries operate downstream of the Lake Vaughan Generating Station (the generating station that is the furthest downstream of the two generating stations on this river). Both blueback herring and alewife are encountered. Counts and biological sampling occur as fish ascend the fish ladder at the Vaughan dam. Counts are considered indicative of spawning escapement because they occur upstream of the fishery.

#### ***Survey methods***

Counts at the fishway are available for the years 2014 and 2015. Monitoring was done via video, and an escapement estimate was obtained via a stratified random count from the video using a two-way design (5 minute blocks, 6 strata per day, four blocks counted per strata). Biological sampling (species, sex, fork length, and a scale sample) occurs by sampling 100 fish per day, where weight measurements are taken on the first 10 fish of each species. Roughly 500 scales were randomly selected, using the number of fish counted per day as a weighting factor, and used to determine ages and previous spawning history.

Some older data exists for river herring in the Tusket River. Some counts and biological sampling for these populations occurred during the mid-1990s and early and late 2000's by different organizations. These data are not compiled in a form which is readily available.

#### ***Sampling Intensity***

Counts and video monitoring take place from the start of the run in late April to the end of the run in late June. Biological sampling also covered the entire run.

#### ***Biases***

Both the biological sampling and counts are considered representative of those fish escaping the fishery but might not be representative of the entire run because the fishing season is closed after May 31st. Fishway efficiency may not be 100%.

### **River Herring Counts at Mactaquac Dam**

River herring are fished commercially in the Saint John River and its estuary. All fisheries operate either downstream of, or at, the Mactaquac Dam. Both blueback herring and alewife are encountered. Counts and biological sampling occur as fish are trapped and trucked above the dam. Counts are considered indicative of spawning escapement because they occur upstream of the fishery. The populations are currently managed using a fixed escapement policy of releasing approximately 800,000 alewife and 200,000 blueback herring above the dam (since 1995). Fish are harvested after the escapement targets are met.

### ***Survey methods***

Counts of the number of fish released are available for the years 1969 to 2015. The number of fish harvested at the dam has been recorded since 1974. Numbers of fish in the escapement were visually estimated as the fish cross a sill into the hopper for loading into tank trucks for transport to the head pond (accuracy thought to be about  $\pm 5\%$ ). A truck is considered full at 2500 fish and the number of trucks filled daily is recorded.

Biological sampling (species, sex, fork length, weight, and a scale sample) protocols have changes through time. Samples of 50 fish were collected weekly throughout the run from the fish-lift between 1973 and 1977, and twice weekly in 1978. Between 1979 and 1994, samples of 100 fish were taken twice weekly, and three times weekly from 1995 to 2000. Sampling protocols were changed variously from 2001 to 2015. Currently, a sample of 50 fish is taken up to 3 times per day for species identification. Beginning in 2011, biological sampling has only included species composition.

### ***Sampling Intensity***

Counts and biological sampling takes place from the start of the run in late April to the end of the run in late June.

### ***Biases***

Changes in water management at Mactaquac Dam have the potential to change the effectiveness of the trap at the dam. Trucking and harvesting at Mactaquac Dam cease before the end of the run and all returns may not be fully enumerated. The fixed escapement strategy means that relatively consistent numbers of blueback herring and alewife are lifted above the dam annually.

### **DFO Maritimes Region George's Bank RV Survey**

Since 1987, a depth stratified random survey of the Georges Bank has been performed during the months of February and March. The annual sampling intensity across the shelf varies between 50 and 150 sets per year.

### ***Survey methods***

This survey is a bottom trawl survey using the Western IIA trawl. During each set temperature, salinity and sampling depth are recorded. Actual trawled distance is recorded for each set and all are standardized to a tow distance of 1.75nm (30min at 3.5 knots). Sampling occurs 24 hours per day.

**Sampling Intensity**

Within the 9 strata sampled, there are between 2 and 25 stations allocated per strata, approximately proportional to strata size, depending on annual survey intensity.

**Biological Sampling**

Fork length (to 1cm) and total weight (to 1g) were measured on most individuals (up to 300 per set) in most years. With special sampling requests, pectoral fin clips were obtained for individual specimens and were preserved either in ethanol or were dried. River herring were not recorded by species prior to 2012.

**Biases**

Being a bottom trawl, this sampling method only covers the bottom ~4m of the water column. As is typical with most trawls, there is a headline-sampling depth relationship such that headline height is reduced during deeper sets. CPUE may not be representative of abundance due to high spatial variability and sampling intensity relative to the survey area.

**Development of Estimates**

Mean number or mean weight per tow are stratified estimates using the tow length adjusted data.

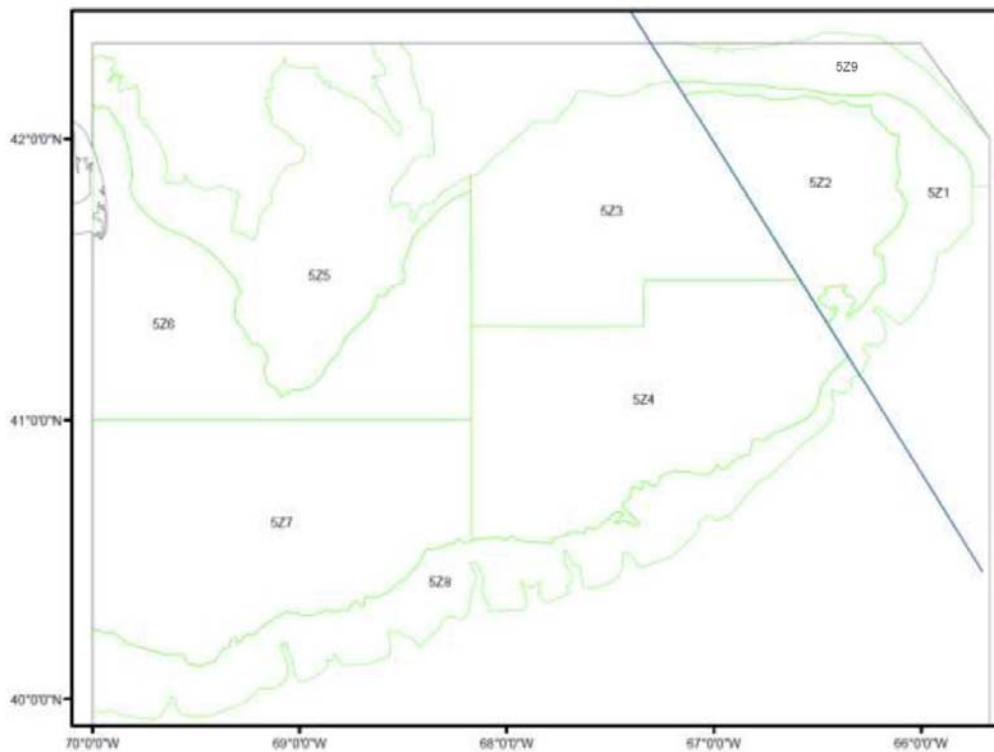


Figure 2: Strata definitions for DFO Maritimes Georges Bank RV survey, blue line indicates Canadian – American boundary.

## **DFO Maritimes Region Summer RV Survey**

Since 1970 a depth stratified random survey of the Scotian Shelf has been performed during the months of June – August. The annual sampling intensity across the shelf varies between 150 and 250 sets per year.

### ***Survey methods***

This survey is a bottom trawl survey. Prior to and including 1981, a Yankee 36 trawl was used, whereas the survey has used a Western IIA trawl since 1982. During each set, temperature, salinity and sampling depth are recorded. Actual trawled distance is recorded for each set and all are standardized to a tow distance of 1.75nm (30min at 3.5 knots). Sampling occurs 24 hours per day.

### ***Sampling Intensity***

Within the 48 strata sampled, there are between 3 and 10 stations allocated per strata, approximately proportional to strata size.

### ***Biological Sampling***

Fork length (to 1cm) and total weight (to 1g) were measured on most individuals (up to 300 per set) in most years. With special sampling requests, pectoral fin clips were obtained for individual specimens and were preserved either in ethanol or were dried. River herring were not recorded by species prior to 2012.

### ***Biases***

Being a bottom trawl, this sampling method only covers the bottom ~4m of the water column. As is typical with most trawls, there is a headline, sampling depth relationship such that headline height is reduced during deeper sets. Near shore habitats are not covered in this survey. CPUE may not be representative of abundance due to high spatial variability and sampling intensity relative to the survey area.

### ***Development of Estimates***

Mean number or mean weight per tow are stratified estimates using the tow length adjusted data.

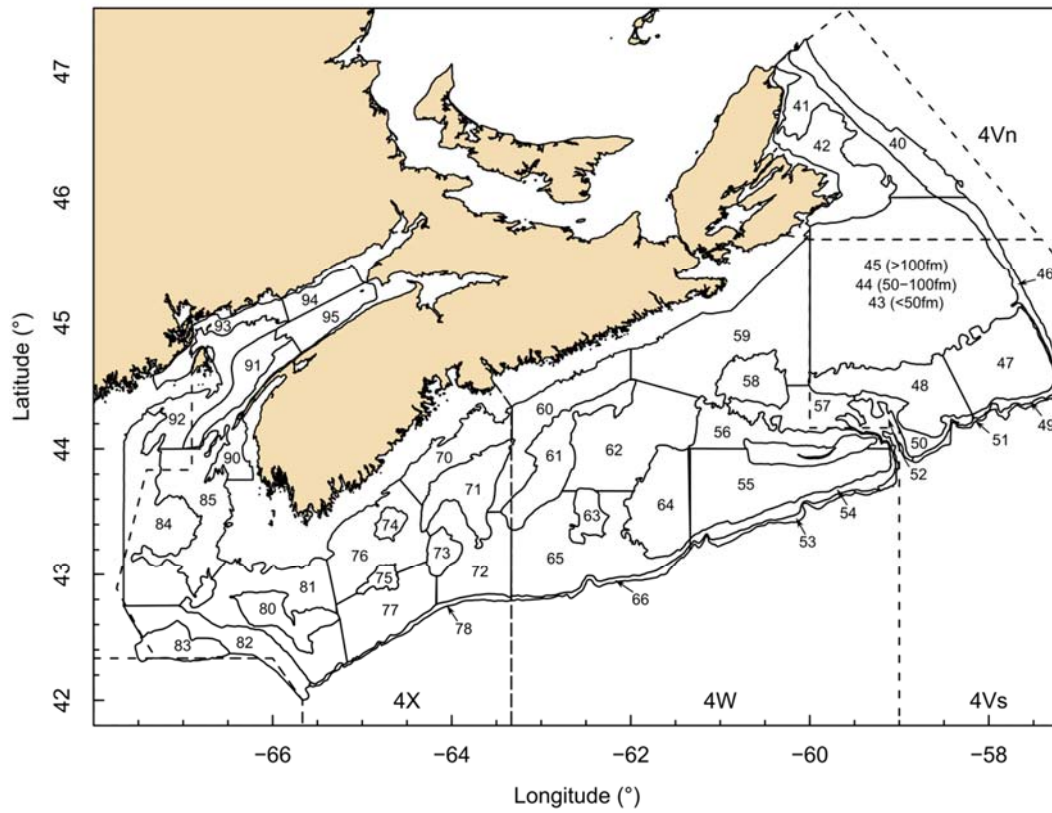


Figure 3: Strata definitions for DFO Maritimes Region Summer RV survey.

## **Appendix C. New Hampshire Fish and Game Department River Herring Monitoring Programs**

**(Mike Dionne)**

### **Fish Ladder Monitoring**

The New Hampshire Fish and Game Department has conducted fish ladder monitoring from 1972 through 2015. The primary objective of the survey is to produce annual estimates of spawning run counts within New Hampshire coastal rivers. This data was used in the last ASMFC stock assessment.

### ***Survey Methods***

Seven fishways on six, coastal, New Hampshire Rivers (Cocheco, Exeter, Lamprey, Oyster, Taylor, and Winnicut rivers) are operated annually from early April to early July, to allow for the passage of river herring, American shad, and other diadromous fish to historical spawning and nursery areas. Each fish ladder is visited daily during peak runs and every few days during periods of little to no passage. All fish passing through the fishways are enumerated by hand passing, daily time counts, or counts estimated by use of Smith-Root Model 1100/1101 electronic fish counters. Hand counts consist of using a stick seine to capture and transfer fish to dip nets, removing all fish from the trap during each visit. Fish are enumerated as each dip net is emptied into the impoundment above the dam. Electronic counters when used are run during all hours of the day, and counts are calibrated each day using a 10 minute time count. Estimates produced in the earliest years of the time series were determined using periodic time counts during the spawning run at each location. There was little standardization on the frequency, timing, and expansion methods used in those time counts. Temperature measurements are collected daily during each visit.

### ***Biological Sampling***

#### *Length Distribution*

Between 1990 and 2015, the length distribution of river herring runs have been sampled annually with three sampling events throughout the spawning run (beginning, middle, end) at each monitored river. During a sampling event, 150 random individuals are collected from within the fish ladder trap and are measured for total length (1990 – 2015) and fork length (2012 – 2015) in millimeters. Length distributions are stratified by river and sex throughout the time series (1990-2015) and also by species since 2010.

#### *Age Distribution*

Age distributions have been estimated annually between 1990 and 2015 using scales. Scales are taken from the area of the fish between the base of the dorsal fin and the lateral line, immediately below the entirety of the dorsal fin. Scales are cleaned and double aged using the methods outlined by Marcy (1969). Age estimates are stratified by river, sex, and species.

Between 1990 and 2008, the age distributions of river herring runs were sampled annually using scale collections during three sampling events throughout the spawning run (beginning, middle, end) at each monitored river. During an age sampling event, 50 random individuals are collected from within the fish ladder trap and a scale sample is taken.

Between 2009 and 2015, a BIN sampling method has been used to estimate the age distributions. A single BIN sample is collected throughout the course of the annual spawning run and is stratified by river, sex, species, and 1 cm increment. A target of five scale samples is obtained for each BIN. The age distribution is then applied to the annual run's length distribution within each river using the resulting age-length key.

### *Species Distribution*

Species distributions have been estimated annually between 1990 and 2015 and are stratified by river and sex. Between 1990 and 2009, sex distributions were determined using scale samples collected, following the methods outlined by MacLellan et al. 1981. Since 2010, species distributions were estimated by visual determination of randomly sampled individuals during each of the three sampling events also used for length distributions. For validation purposes, the visual field identification is recorded on all scale samples collected and then species is determined during reading without prior knowledge of the field identification. Species distributions are stratified by river.

### ***Qualitative Assessment***

This monitoring includes nearly complete enumeration of all spawning river herring returning to major coastal rivers in New Hampshire. It is likely an underestimate of total abundance of river herring, as passage efficiency of the fish ladders is less than 100% and it likely excludes the smallest fish from the population as they have been sampled below the fish ladders. This survey is thought to be very reliable and the best available information on river herring populations within New Hampshire.

### **NH Juvenile Finfish Seine Survey**

The New Hampshire Fish and Game Department has conducted a juvenile finfish seine survey continuously from 1997 through 2015. The primary objective of the survey is to produce annual estimates of relative abundance (geometric mean CPUE) of juvenile fish species in New Hampshire bays and harbors. This data was not used in the last ASMFC stock assessment.

### ***Survey Methods***

#### *Design*

The Juvenile Finfish Seine Survey is a fixed station survey. Fifteen fixed stations were chosen through sampling several sites within New Hampshire bays and estuaries in the years before 1997 and selected based on habitat type, depth of less than 2m, and with low enough tidal current to allow for the net to

be pulled through the site. The stations, four of which are in the Hampton/Seabrook Estuary, three in Little Harbor, three in the Piscataqua River, and five in Little Bay/Great Bay, are representative of juvenile finfish nursery habitat along New Hampshire's coastal waters. The survey design has remained unchanged throughout the time series with only a few fixed stations moving slightly due to environmental changes such as sand bar shifts.

### *Sampling Gear*

The beach seine used for this survey is a bag seine, 30.5 m long by 1.8 m high, with 6.4 mm mesh.

### *Sampling Methods*

A single seine haul is performed at each station each month from June through November, resulting in 90 tows per year. Seine hauls are performed between two hours before and two hours after low tide, and always in daylight. Seine hauls are set by boat about 15-25 m from the beach and, ideally, in water depths less than 2 m, in order to prevent the foot rope of the seine from lifting off of the bottom.

### ***Biological Sampling***

All captured finfish are identified to the lowest possible taxon, measured in total length to the nearest millimeter (with a maximum of 25 individual lengths recorded per species per seine haul), and then enumerated. Water surface temperature (°C), salinity (ppt) and substrate type are recorded at each fixed station for each seine haul.

### ***Qualitative Assessment***

The survey is designed to sample all species and occurs only in the months of June through November. Both species of river herring are encountered in the survey, however, the frequency of sampling and location of sampling sites is not directed spatially or temporally towards locating juvenile river herring. While the relative index is useful for inclusion in the seine survey's widespread sampling design, it is not thought to be very informative on river herring specifically.

### **Coastal Harvesters Reporting**

The New Hampshire Fish and Game Department allows individuals to use nets and other fishing gear types to harvest (i.e. cast nets, weirs, gill nets) finfish within the tidal waters of the state. Since 1989, individuals obtaining these permits have been required to report their harvest monthly on paper reporting sheets supplied by the department. The primary objective of the survey is to produce annual estimates of harvest in numbers and weight of finfish species taken from New Hampshire tidal waters. This data was used in the last ASMFC stock assessment.

### ***Survey Methods***

Fishermen are required to submit written reports detailing their catch and harvest of all species of finfish using various types of gear other than angling. The required elements to be reported are in accordance



with Atlantic Coastal Cooperative Statistics Program standards and include; date fished, trip number, species sought, quantity of species retained, disposition of the harvest, area fished, gear type, number and size of gear, effort (in hours), number of sets and quantity of bycatch by species. If the individual used a boat or sold their catch, the following elements are also required; port/county/state harvest landed, hours at sea, number of crew, dealer license number, and unloading date. The reports are required to be submitted by the tenth day of the following month for those months the individual is permitted to harvest, whether or not effort occurred. Permits for subsequent years are not issued to an individual until the previous years' reporting requirements have been met.

The harvest information is reported in either weight or quantity. All quantitative data are converted to weight. Harvest pounds, effort, and catch per unit effort (CPUE) data are compiled by species.

### ***Qualitative Assessment***

This is the only source of river herring harvest through methods other than angling in New Hampshire state waters. The data is reported by the harvester and not verified by biologists; therefore it relies on accurate reporting and species identification by the harvester. The department believes that the reported catch and harvest are sufficiently reliable, but does not think the speciation of river herring specifically is accurate.

## **Appendix D. Massachusetts Division of Marine Fisheries River Herring Monitoring Programs**

**(Ben Gahagan)**

### **Spawning Run Surveys**

Massachusetts Division of Marine Fisheries (DMF) currently conducts abundance surveys on 6 river herring runs and biological monitoring of 8 runs in coastal Massachusetts. Historically, the majority of population abundance monitoring has been conducted by volunteer groups or municipalities, in some cases with the assistance of DMF. Visual counts with statistical design typically relied on Rideout et al. (1979) until DMF published a revised protocol (Nelson, 2006). In 2015, an additional 14 runs were monitored using high accuracy methods (video, manual counts, Smith-Root 1101 and Smith-Root 1601) and visual estimates were made at an additional 19 runs. All counts were conducted at fishways unless otherwise noted.

River herring for biological samples are collected using dip or cast nets. DMF staff obtains 100 adults per week, records TL, sex, species and individual weight, and removes otoliths and scales. Tissues for genetic samples are retained upon request. Otoliths are subsampled to provide adequate sample size for analyses by species, sex, and length (as a proxy for age).

### ***Runs Surveyed***

*Acushnet River* (New Bedford) - Since 2005, DMF has conducted a census of river herring entering the spawning ground using a fish trap. Simultaneous estimation of passage by using a SR-1101 electronic counter began in 2008, and video counting was attempted in 2008. DMF has also collected biological samples from dead fish, but samples were non-random and sample sizes were small. This river was not included in the 2012 assessment.

*Alewife Brook* (Essex) – In 2014 DMF began monitoring the abundance of Alewife using a SR-1601 electronic counter. The counter is installed directly in the river as there are no dams or fishways on this system. There are no biological data available. This river was not included in the 2012 assessment.

*Agawam River* (Wareham) - The town of Wareham has been estimating combined (*ie* Alewife and Blueback Herring) passage using a SR-1101 electronic counter since 2006. Biological data are available from only 1991. Biological data was used in the 2012 assessment.

*Back River* (Weymouth) - The town of Weymouth's herring warden provides a "relative" passage estimate from his daily observations of run activity. No statistically-valid design is used. In 2007, DMF characterized the Alewife population. DMF collected biological data on size structure, sex composition, age structure, length-weight relationships and length-at-age relationships of spawning populations. In 2015, DMF installed a SR-1601 electronic counter at the exit of the final fish ladder and resumed collecting biological data. Biological data from this river were included in the 2012 assessment.

*Bound Brook* (Scituate) - The North and South Rivers Watershed Association began Alewife passage counts using visual estimation in 2010. No statistical design was used. There are no biological data available. This river was not included in the 2012 assessment.

*Charles River* (Boston) - The University of Massachusetts with assistance of DMF conducted combined video counts in 2008 and 2009. DMF conducted independent video counts in 2013 and 2014. Biological data are available from 1985, 1993, 2013, and 2014. Biological data from the Charles were used in the 2012 assessment.

*Connecticut River* (Holyoke) - Fishlift counts have been made at the Holyoke Dam since 1967 for Blueback Herring by the US Fish and Wildlife Service. The numbers are used by the State of Connecticut in their river herring assessment; therefore, the information is not discussed herein to avoid duplication of effort. USFWS Connecticut River currently monitors adult river herring populations in the River.

*Coonamessett River* (Falmouth) - Falmouth Department of Natural Resources has been estimating passage using visual estimation from an overpass since 2005. There are no biological data available. This river was not included in the 2012 assessment.

*Herring Brook, First* (Scituate) - The North and South Rivers Watershed Association conducted Alewife passage counts using visual estimation in 2005-2006 and 2011-12. No statistical design was used. There are no biological data available. This river was not included in the 2012 assessment.

*Herring Brook, Second* (Norwell) - The North and South Rivers Watershed Association conducted Alewife passage counts using visual estimation in 2005-2006. No statistical design was used. There are no biological data available. This river was not included in the 2012 assessment.

*Herring Brook, Third* (Norwell/Hanover) - The North and South Rivers Watershed Association conducted Alewife passage counts using visual estimation in 2003, and 2005-2006. No statistical design was used. There are no biological data available. This river was not included in the 2012 assessment.

*Herring River* (Wellfleet) - The Association to Preserve Cape Cod has been estimating combined passage numbers using visual counting since 2007. There are no biological data available. This river was not included in the 2012 assessment.

*Herring River* (Harwich) - The Association to Preserve Cape Cod has been estimating combined passage numbers using visual counting since 2007. In 2013, DMF began collecting biological samples at this site and plans to install a SR-1601 electronic counter in 2016. This river was not included in the 2012 assessment.

*Ipswich River* (Ipswich) - The Ipswich Watershed Association has been estimating combined passage using visual counting since 2000. They've attempted to use the statistical design of Rideout et al. (1979) but prior to 2005, effort was not sufficient to provide reliable estimates. In 2006 -2008, DMF also made census counts by using a fish trap. In 2015, the Watershed Association installed a video counting system. There are no biological data available. This river was not included in the 2012 assessment.

*Jones River* (Kingston) - The Jones River Watershed Association has been conducting combined passage counts using visual estimation since 2005. There are no biological data available. No statistically-valid design was used in earlier years but the group now uses the Nelson 2006 method. This river was not included in the 2012 assessment.

*Little River* (Gloucester) - Massachusetts Audubon made Alewife passage counts using visual estimation during 2000-2002, 2005, and 2009 and no statistically-valid design was used. Beginning in 2011, the City of Gloucester coordinated a count using the methods of Nelson 2006. There are no biological data available. This river was not included in the 2012 assessment.

*Marston-Mills River* (Marston-Mills) - Starting in 2007, a local watershed group made visual counts of combined herring passage at Mill Pond dam in the Marston-Mills River. They use a stratified random design. There are no historical or current data on population characteristics. This river was not included in the 2012 assessment.

*Mattapoissett River* (Mattapoissett) - Since 1988, Alewives Anonymous has provided passage counts of Alewife using an electronic fish counter. Harvest data are also provided. In 1995, 2006 and 2007, DMF collected biological data on size structure, sex composition, age structure, length-weight relationships and length-at-age relationships of spawning populations. Abundance and biological data from this river were used in the 2012 assessment.

*Merrimack River* (Lawrence) - Counts of diadromous fish, including river herring, are performed by Massachusetts Division of Fish and Wildlife technicians at a viewing window upstream of the lift at Essex Dam in Lawrence. Population abundance has been shown to be closely related to active restoration activities in the watershed (*ie* trap and transport) rather than natural trends. Biological monitoring of Alewife and Blueback Herring on the Merrimack began in 2014. This river was not included in the 2012 assessment.

*Monument River* (Bournedale) - DMF has been scientifically monitoring the abundance, sex composition, length structure, age composition and removals of Alewife and Blueback Herring in the Monument River since the early 1980s (Churchill, 1981; O'Hara, 1980; Brady, 1987a, b). Prior to 1985, abundance was estimated by using visual counts following the statistical design of Rideout et al. (1979). Since 1985, escapement has largely been estimated by using a Smith-Root 1100 or 1101 electronic fish counter that is calibrated daily. In 2014, DMF began using a SR-1601 counter to improve accuracy. DMF often uses herring from this river as donor stock to other river systems. All numbers transported are added to harvest recorded by the Bournedale fish warden to get total number of removals. Scale ages are only available for 1984-1987, 1993, and 1995-2012. Otolith ages are available from 2013-2015. Since the counting location is not far above the catchment basin where herring are removed, and both are close to the river mouth, the total run size is estimated by adding escapement counts to removal numbers. Abundance and biological data from this river were used in the 2012 assessment.

*Mystic River* (Boston) - Since 2004, DMF has characterized the Alewife and Blueback populations. DMF has collected biological data on size structure, sex composition, age structure, length-weight

relationships and length-at-age relationships of spawning populations. Ages were obtained from scales from 2004-2012 and otoliths from 2012-2015. The Mystic River Watershed Association began a visual count in 2012 following the protocol of Nelson 2006. Biological data from the Mystic were used in the 2012 assessment.

*Nemasket River* (Middleboro) - Since 1996, the Middleboro-Lakeville Herring Commission has provided visual counts of Alewife passage at the fishway off Wareham Street (river mile 7.5). The statistical design of Rideout et al. (1979) was used until 2010 and Nelson 2006 has been used since then. Since 2004, DMF has characterized the Alewife population of this river. Since 2004, DMF has collected biological data on size structure, sex composition, age structure, length-weight relationships and length-at-age relationships of spawning populations. Ages were obtained from scales until 2012 and from otoliths beginning in 2013. While not sampled, Blueback Herring are found within the Nemasket. Abundance and biological data from this river were used in the 2012 assessment.

*Parker River* (Newbury) - Students and researchers at the University of Massachusetts, Amherst conducted several studies during the 1970s that provide information on juvenile and adult population characteristics, abundance and migration of Alewives (Beltz, 1975; Cohen, 1976; Cole et al., 1976; Cole et al., 1978; Huber, 1974; Jimenez, 1978; Libey, 1976; Mayo, 1974; Rideout et al., 1979). Since 1997, the Parker River Clean Water Association has been estimating passage numbers at the first dam using visual counting and the statistical design of Rideout et al. (1979). In 2011, DMF began collecting biological data from Alewife and Blueback Herring in the Parker River. Fish were aged using scales in 2011 and with otoliths since 2012. In 2013, MDMF installed a Smith-Root 1601 counter at the fishway exit, however use of the fishway by sea lamprey (*Petromyzon marinus*) reduced count accuracy and an infrared illuminated video system was used in 2014-2015. Comparisons of the SR-1601 and video system have shown volunteer counts at this site to underestimate the abundance of the population. Abundance data were used in the 2012 assessment.

*Pilgrim Lake* (Orleans) – The Association to Preserve Cape Cod has provided abundance estimates of Alewife passage using visual counting and a stratified random design since 2008. This river was not included in the 2012 assessment.

*Quashnet River* (Falmouth/Mashpee) - In 2004, DMF characterized the Alewife population. DMF collected biological data on size structure, sex composition, age structure, length-weight relationships and length-at-age relationships of spawning populations. A visual count using 10 minute counts and stratified random design has been conducted on the Quashnet since 2013. Biological data were used in the 2012 assessment.

*Sippican River* (Wareham) - Alewives Anonymous made electronic census counts of Alewife passage in 1995-2002, 2006, and 2013-2014. There are no biological data available. This river was not included in the 2012 assessment.

*South River* (Marshfield) - The North and South Rivers Watershed Association conducted passage counts using visual estimation in 2006, 2008, 2010, and 2012-2013. No statistical design was used. There are no biological data available. This river was not included in the 2012 assessment.

*Stony Brook* (Brewster) - The Association to Preserve Cape Cod has provided estimates of Alewife passage numbers at the lower Mill Pond dam using visual counting and a stratified random design since 2007. In 2004, DMF characterized the Alewife population. DMF collected biological data on size structure, sex composition, age structure, length-weight relationships and length-at-age relationships of spawning populations. Mr. George A. Kurlycheck, a Middle School teacher in Harwich, collected average size data on Alewife (sexes combined) from 1978-2001. Biological data from Stony Brook were used in the 2012 assessment.

*Town Brook* (Plymouth) - Since 2004, DMF has characterized the Alewife and Blueback populations. DMF has collected biological data on size structure, sex composition, age structure, length-weight relationships and length-at-age relationships of spawning populations. Ages were obtained from scales until 2013 when DMF began using otoliths. The town of Plymouth, University of Massachusetts, and DMF have made visual counts since 2008 and video counts were made in 2008 and 2009. A SR-1101 was used from 2010-2012. Biological data were used in the 2012 assessment.

*Town River* (Bridgewater) - The town of Bridgewater has made combined SR-1101 electronic passage counts of river herring (species combined) since 2000. There are no biological data available. Abundance data were used in the 2012 assessment.

*Trunk River* (Falmouth) - Falmouth Department of Natural Resources has been estimating passage since 2008. No statistical design is used. There are no biological data available. This river was not included in the 2012 assessment.

*Wankinco River* (Wareham) - The town of Wareham has made combined SR-1101 electronic passage counts since 2007. There are no biological data available. This river was not included in the 2012 assessment.

### **Portside Sampling Program**

In 2008, DMF began a Portside Sampling Program to better quantify and characterize the bycatch of river herring in pelagic (mid-water and small mesh bottom trawl) fisheries. Data from this program provide trip level, rather than tow level, information. From 2008-to 2011 the program used a modified Northeast Fishery Observer Program (NEFOP) protocol and conducted 1. lot samples, 2. plant samples, and 3. sub-samples of unsorted offloads. Analyses conducted in 2010 and 2011 comparing the Portside Sampling Program found that plant and lot samples were not comparable to NEFOP trip statistics but that sub-samples of unsorted offloads were comparable and often had lower variance than NEFOP trips. Since 2012 DMF has collected sub-samples of unsorted offloads. Annual coverage exceeds 50% of landings from both the mid-water and small mesh bottom trawl fleets.

The Portside Sampling Program gathers information on target and priority species. River herring and shad are priority species and length frequencies are created for each offload. Sampled river herring are collected and frozen. After thawing, DMF staff records TL, sex, species, individual weight, maturity, and remove otoliths. Tissues from genetic samples are collected upon request. Results from this program

are available in the peer reviewed literature (Bethoney, Schondelmeier, Stokesbury, & Hoffman, 2013; Bethoney, Stokesbury, Schondelmeier, Hoffman, & Armstrong, 2014).

### **Resource Assessment Survey**

The DMF Resource Assessment Survey has occurred in Massachusetts state waters in the spring and fall of each year since 1978. All survey from 1978-1981 were conducted on the F/V Frances Elizabeth. Since 1982 surveys have been completed on the R/V Gloria Michelle. Trawl design and doors have been consistent throughout the duration of the survey. The study area is stratified based on five biogeographic regions and six depth zones. Sampling intensity is approximately 1 station per 19 nmi<sup>2</sup>. Stations are assigned in proportion to the area of each stratum (Figure 2). A minimum of two stations are assigned to each stratum. In 2005, station assignments were updated to reflect improved stratum area estimates. A net addition of 2 stations brought the total assignment up to 103. Survey timing is planned for availability of adult finfish in the inshore waters in spring (May) while the fall survey (September) is intended to sample juveniles prior to migration beyond state waters.

Since 1982, stations have been assigned a priori by a random selection process. Any randomly selected station that is identified as being on an untowable site (based largely on previous survey experience) is rejected and another random selection is drawn. Hard bottom habitats, identified as untowable from previous experience, have effectively been removed from the station selection process.

All tows are conducted during daylight hours. A standard tow of 20 minutes duration at a speed of 2.5 knots is executed after reconnaissance at each site to assure a clear path. Catch data from tows of  $\geq 13$  minutes, but  $< 20$  minutes are expanded to the 20 minute standard and coded as acceptable,. Both standard and acceptable tows, are considered representative. Tows of less than 13 minutes duration are considered non-representative and are excluded from most indices. Standard bottom trawl survey techniques are used when processing the catch. The total weight and length frequency are recorded for each species on trawl logs. Sampling protocols and survey design largely follow the methods established by the Northeast Fisheries Science Center. Total aggregate weights are recorded to the nearest 0.1 kg for each species. Lengths for each finfish species are measured along the midline to either fork or total length. Otoliths have been extracted from a subsample of river herring collected on the spring cruise beginning in 2014.

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## **Appendix E. Rhode Island Department of Environmental Management River Herring Monitoring Programs (Phil Edwards)**

### **Spawning Stock Size Surveys**

#### *Gilbert Stuart*

The Alaskan steep pass at Gilbert Stuart has been the primary survey site for monitoring adult river herring since 1981. The Division has estimated spawning stock size since 1981 using electronic fish counters or direct count methods. River herring were sampled for biological data during two time periods. The first sampling period was between 1980 and 1992, and the second from 2000 to present. The break in the biological data time series between 1993 and 1999 was due to changes in staff, but spawning stock size estimates were continued during this time period. River herring were sampled and measured for length, weight, and scale samples were taken for age analysis. Approximately 50 Alewives were sampled three times throughout each spring migration. Mortality rates and percent of repeat spawners is estimated. Past data and results from Gilbert Stuart were used in the last assessment.

#### *Nonquit*

The Denil fishway at Nonquit has been the survey site for monitoring adult river herring since 1999. The Division has estimated spawning stock size at Nonquit since 1999 using a solar operated electronic Smith-root fish counter. The only other known data, which included run size estimates, were collected in 1976. No other historic biological data is available from Nonquit prior to 1999. River herring were sampled for biological data since 2000, except for in 2010 when river herring were unable to be captured after numerous attempts. River herring were sampled and measured for length, weight, and scale samples were taken for age analysis. Approximately 50 Alewives were sampled three times throughout each spring migration. Mortality rates and percent of repeat spawners is estimated. Past data and results from Nonquit were used in the last assessment.

#### *Buckeye Brook*

The Buckeye Brook Coalition and Division partnered in 2003 to initiate a direct count program utilizing volunteers (Puriton 2000; Stevenson 1997). Buckeye Brook is a free-flowing system and river herring migrate to Warwick Pond without obstruction. The connection between Warwick Pond and Spring Green Pond passes through the T.F Green Airport property. Recently, T.F Green Airport completed modifications to enhance river herring access to Spring Green Pond. River herring have not been sampled for biological data, nor have JAI's been performed at Buckeye Brook. Spawning stock size estimates were used in the last assessment.

#### *Pawcatuck River*

A fishway trap is installed and operated each spring to monitor American shad returns.

The increased number of river herring compared to American shad and high water volume make utilizing the fishway trap unfeasible for estimating river herring run size. Direct count techniques have failed, due to visibility and electronic counters are not efficient at the site. Since 2006, in addition to observations (presence/absence) the Division has initiated a four factor ranking system in which personnel estimate the number of herring in the trap and fishway each day the trap is checked for American shad.

#### *Gorton, Hunt, Ten Mile, Woonasquatucket, & others*

Shorter time series initiated by local watershed groups utilizing direct count methods include Gorton Pond (2010), Hunt River (2010), Ten Mile River (2015) and Woonasquatucket River (2011). Spawning stock size estimates were recorded, but no biological data has been collected at this time from the above sites. At other Rhode Island river herring systems, the Division conducts periodic qualitative analysis which consists of determining the presence and absence of adult and juvenile river herring. Methods include random net surveys, visual observations and electrofishing to determine spawning success.

#### **Juvenile Abundance Index Surveys**

*Gilbert Stuart*- freshwater- Between 1988 and 1996 a trapnet was installed weekly during the fall capturing juveniles exiting the freshwater impoundment. The trapnet was connected to the exit of the Alaskan steep pass fishway, therefore trapped fish endured high velocities of water. Due to high juvenile mortality the JAI was discontinued in 1996. During the 2007 season a different style trapnet, which prevents juvenile mortality was utilized. This weir based trap located 200 yards below the fishway allows trapped out-migrating juveniles a safe holding pen. The trap is set for one hour and juveniles are enumerated and length measurements are collected. Relative abundance indices are estimated and expressed in mean number per one hour trap set.

*Nonquit*- freshwater- Since 2001 a trapnet was installed weekly each fall in the Denil fishway. The trap is placed in the slots at the front of the turning pool, and juveniles are captured as they exit the freshwater impoundment and held in the turning pool. The trap is set for one hour and juveniles are enumerated and length measurements are collected. Relative abundance indices are estimated and expressed in mean number per one hour trap set.

*Pawcatuck River*-estuarine- Seine survey conducted weekly each fall since 1986 at five fixed stations in the lower Pawcatuck River (O'Brien 1986). Relative abundance indices are estimated, and expressed in mean number per seine haul. Juveniles are enumerated and length measurements are collected. Majority of the samples collected are juveniles but occasionally age one river herring are captured and reported with the length frequency data.

*Remaining Rhode Island Runs*- Periodic qualitative analysis which consists of determining the presence and absence of adult and juvenile river herring in selected Rhode Island systems. Methods include random net surveys, visual observations and electrofishing to determine spawning success.

### **Anadromous Fish Electrofishing Surveys**

River herring were collected primarily by electrofishing in selected ponds and the main stems of large nonwadeable rivers with suitable access, at night, with a Smith-Root Model SR-16H electrofishing boat that was equipped with a 7.5-GPP control box and a pair of one-meter umbrella anode arrays each equipped with six stainless steel droppers. The cathode is insulated from the hull and mounted across the bow. In ponds smaller than 50 acres (20 ha), electrofishing was conducted along the entire length of the shoreline. The shorelines of lakes larger than 50 acres were divided into 12 sampling areas. Sampling was conducted at a single location that was randomly selected within each sampling area in an attempt to sample all the major littoral habitat types. Electrofishing catch rates and total length measurements were collected for river herring.

### **Rhode Island Coastal Trawl Surveys**

Trawl Survey-Marine - The methodology used in the allocation of sampling stations employs both random and fixed station allocation. Fixed station allocation began in 1988 in Rhode Island and Block Island Sounds. This was based on the frequency of replicate stations selected per depth stratum since 1979. With the addition of the Narragansett Bay monthly segment which started in 1990, an allocation system of 13 fixed stations was employed. Sampling stations were established by dividing Narragansett Bay into a grid of cells. The seasonal trawl survey is conducted in the spring and fall of each year. Usually 44 stations are sampled each season; however this number has ranged from 26 to 72 over the survey time series. The stations sampled in Narragansett Bay during the seasonal segment are a combination of fixed and random sites. Thirteen fixed during the monthly portion and 26, (14 of which are randomly selected) during the seasonal portion. The random sites are randomly selected from a predefined grid. All stations sampled in Rhode Island and Block Island Sounds are fixed.

#### Depth Stratum Identification:

Area	Stratum	Area nm2	Depth Range (m)
Narragansett Bay	1	15.50	<=6.09
	2	51.00	>=6.09
Rhode Island Sound	3	0.25	<=9.14
	4	2.25	9.14 – 18.28
	5	13.5	18.28 – 27.43
	6	9.75	>=27.43
Block Island Sound	7	3.50	<=9.14
	8	10.50	9.14 – 18.28
	9	11.50	18.28 – 27.43
	10	12.25	27.43 – 36.57
	11	4.00	>=36.57

At each station, an otter trawl equipped with a ¼ inch liner is towed for twenty minutes covering .83 nautical miles. Data on wind direction and speed, sea condition, air temperature and cloud cover as well as surface and bottom water temperatures, are recorded at each station. Catch is sorted by species. Length (cm/mm) is recorded for all finfish, skates, squid, scallops, lobster, blue crabs and horseshoe crabs. Similarly, weights (gm/kg) and number are recorded for each species (Lynch 2007). The survey is a random / fixed stratified trawl survey that operates throughout state waters. Adults and juveniles are collected. The trawl survey net is towed for 20 minutes at 2.5 knots. Mean number per tow and mean biomass per tow were estimated for target species and river herring were subsampled for fork length measurements. Water temperature, depth, and weather conditions are recorded at each sampling site (Olszewski 2014).

#### **Narragansett Bay Seine Survey**

Narragansett Bay Seine Survey- marine- Since 1988, eighteen stations have been sampled monthly from June through October. The survey is a fixed station seine survey using a 200ft seine net that samples throughout Narragansett Bay. Relative abundance indices are estimated, and expressed in mean number per seine haul. Predominately juveniles are collected. Length frequency and numbers collected are recorded. Water quality parameters temperature, salinity and dissolved oxygen, are measured at each station using an electronic sampling device (McNamee 2015).

## **Coastal Pond Juvenile Finfish Seine Survey**

The RIDFW Coastal Pond Juvenile Finfish Survey has been collecting data on fish populations in the salt ponds since 1993. The survey takes place between the months of May and November annually. Survey data is used to forecast recruitment in relation to the spawning stock biomass of winter flounder and other recreationally important species. Currently the ponds being sampled are Winnipaug, Quononchontaug, Ninigret, Point Judith Pond, Potter's, Green Hill, Little Narragansett Bay, and the Narrow River. The fish are collected with a 16 foot aluminum boat deploying a beach seine 130 ft. long, 5.5 ft deep with ¼" mesh. The seine is set in a semi-circle, along the shoreline and hauled toward the beach by hand (Lake 2014). All animals collected are identified to species, measured, and enumerated. Relative abundance indices are estimated, and expressed in mean number per seine haul. Majority of the samples collected are juveniles but occasionally adults are captured and reported with the length frequency data. Every effort is made to return the fish to the ponds alive. Water quality parameters temperature, salinity and dissolved oxygen, are measured at each station using an electronic sampling device.

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## **Appendix F. U.S. Fish and Wildlife Service Connecticut River River Herring Monitoring Program**

### **(Ken Sprankle)**

The USFWS Connecticut River Coordinator's Office initiated a population monitoring program for river herring beginning in the spring of 2013, following the ASMFC SA priority data needs. This assessment is intended to continue into the future as its goals are to determine status and trends for both Blueback Herring and Alewife population metrics to aid in future ASMFC stock assessment and the Connecticut River Atlantic Salmon Commission's restoration plan goals.

#### ***Survey Methods***

An 18ft boat electrofisher is used to sample targeted geographic areas, principally in lower tributaries and coves from early April through June (Figure 1). Sampling effort is standardized for two dip netters, using long handled nets off the bow deck. Fish sampling is conducted from an upstream to downstream direction at a rate of approximately 3 mph, or a rate of speed as necessary with increased currents or eddies. Timed runs, of 500 seconds, based on efisher "on time" are used as a sampling unit with replicates, often 4-7 runs per date and location is completed. Netters apply power in bursts using foot pedals at the bow, for approximately 3 seconds, and then go "off" for a similar time to prevent the pushing of fish ahead of the boat to the extent possible.

River herring are the priority target species and all possible stunned individuals in the boat's field are attempted for capture by the two netters. Fish are placed in the live well until the 500 second sample period is completed. The boat is then directed and run back upstream; several hundred meters to process that run's catch. Each data sheet identifies sampling site and equipment data settings and other data. Fish are clearly assigned to each sample "run" on the data sheets. Species, sex, total length and fork length, and weight are recorded, along with noting other species observed. Depending on catch rate, such as in early season, all fish will be retained to ensure a target minimum 50 fish sample to the laboratory. Fish are individually placed in ziplock baggies that are numbered and correspond to individual measurements on data sheets that are identified by the same number.

In the event fish catch rates are high, as in obtaining well over 75 fish in under 300 seconds of effort, subsampling may occur. Efishing may be ended prior to reaching 500 seconds of "on-time" in the interest of distributing the sample among multiple run locations, with batches of fish bagged and retained by run (i.e., 15 per run) in an attempt address cluster sampling concerns. In the event of high catch rates, the number of reduced seconds fished will be noted on the data sheet for later data entry. This adaptive sampling approach will often result in a sample of up to several hundred measured fish and will allow more runs to be conducted than would otherwise be possible at peak run times.

Otolith extraction procedures follow Massachusetts Division of Marine Fisheries (MADMF), Aging Laboratory guidance, and includes placement in 5ml vials, with unique number assignments, with lids off until next day to allow for air drying. Scales are removed (MADMF procedures) and placed in scale envelopes that also identify back to individual fish record, and lists length and weight data.

Field data sheet are entered into an ACCESS database that identified sampling areas by codes, date, run, and each fish captured that are either taken to the lab or processed on the boat for data (sex, lengths, etc.). Unique ID code for all fish that were sampled for age structures are assigned and identified in the database and on otolith vial labels. Later age determinations will be entered in this file, with reader initials and level of confidence. Fish that are identified by species, counted and released (high volume sampling) are noted in a separate EXCEL file that is used for relative abundance measures, reported as fish per minute, based on total fish captured, not only what was measured on board vessel.

### ***Sampling Intensity***

Sampling is initiated in the most the downstream sites (Mattabessett River, CT) in early to mid-April, dependent on water temperatures, targeting Alewife. Sampling intensity (frequency) will increase in later April as Blueback Herring begin to show in numbers and fish begin to reach more upstream target sample areas. Sampling progresses from Mattabessett to Wethersfield Cove, Farmington River (all CT) and then slightly later (early May) in Westfield River (MA) and Chicopee River (MA). It is not possible to sample all of the target areas at a consistent frequency/intensity over the full study period. It is not possible to obtain Alewife samples in any number upstream of Wethersfield Cove. These factors result in some trade-offs in timing of effort that has remained relatively consistent on that south to north gradient, partially driven by species occurrence and timing of species runs.

### ***Biases***

Boat e-fishing, fish sampling effectiveness is impacted by water visibility, depth, netter proficiency, and variation in electrical field settings that are modified based on water conditions, fish responses, and capture success, every time out. The relationships and effects on CPE are not empirically clear. The effect on actual obtained fish samples for lab and age /spawning determination, sizes etc., and (primary survey goal) is not a likely concern compared to CPE as noted. It does not seem unreasonable to assume there is no differential behavior of age/size fish capture probability at sites. Timing of collected samples among areas and in relation to year to year variability is a potential concern. The data must be examined to determine if there are differences in from “early, mid and late run”; age, sex, sizes before being compiled for summaries by sample area. Some preliminary analyses have shown statistically significant differences in these measures (e.g., length by sex) within year (temporal) and among sites (spatial).

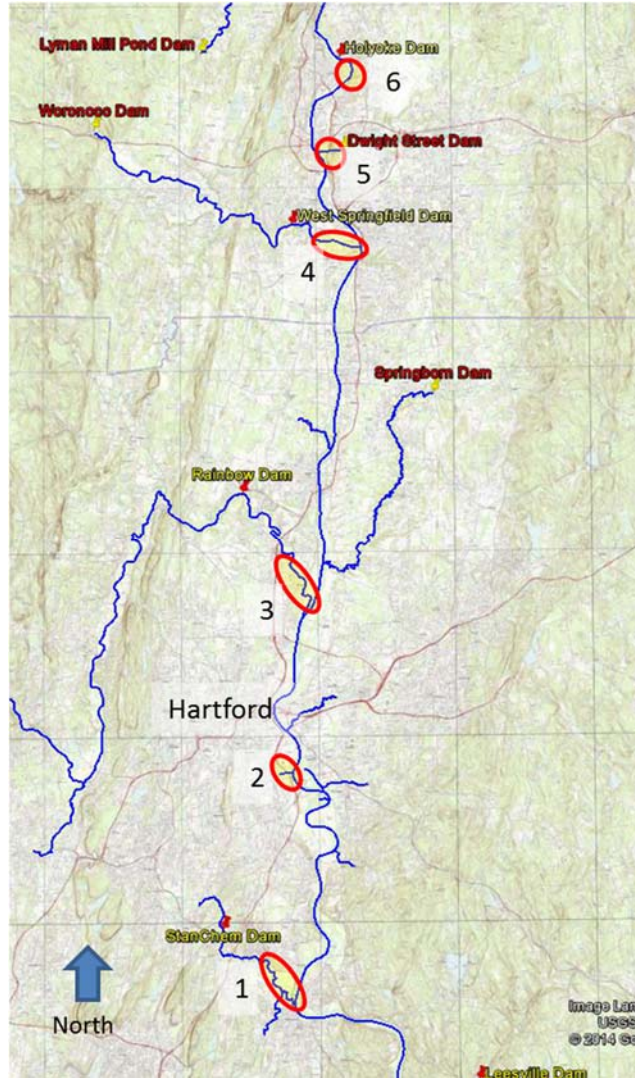
### ***Biological Sampling***

River herring total length, fork length, sex, weight all recorded in field for up 50 fish per timed run. Counts are then made above that cut-off, with fish released immediately (for CPE use only). A target minimum of 50 fish back to lab may range up to 75 or greater, at higher catch periods, for otolith extraction, checking of sex/spp, scale removal. Total Blueback sample size (processed fish) 2013-2015 (n= 4,300); total Alewife processed sample size (n=586). Laboratory processed fish for otoliths/scales have ranged between 500-700 Blueback Herring and 125-250 Alewife annually, with increased effort/sample sizes in the last two years.



## Development of Estimates

Data are all draft, estimates on CPE (individual, summed, aggregated...), size metrics -age structure, spawning history, (within site, between sites, among years and sites) are all in process.



**Figure 1. Adult river herring population assessment field sampling locations:**

- 1) Mattabesset River; 2) Wethersfield Cove; 3) Farmington River;
  - 4) Westfield River; 5) Chicopee River; 6) Downstream of Holyoke Dam
- (Images from/using Google Earth)

### Additional Connecticut River Main Stem Sample Areas

- 1) River left, main stem shoreline Glastonbury, Keeney Cove and further downstream, CT
- 2) Shallow gravel area off of Salmon Brook, Glastonbury, CT
- 3) Vicinity of Dexter Coffin Bridge, near outlet of Windsor Locks Canal, CT
- 4) Shallows upstream of old Enfield Dam, CT

Plots of individual USFWS boat electrofishing survey sample runs  
in Connecticut River basin for blueback herring  
spring of 2013, 2014, and 2015

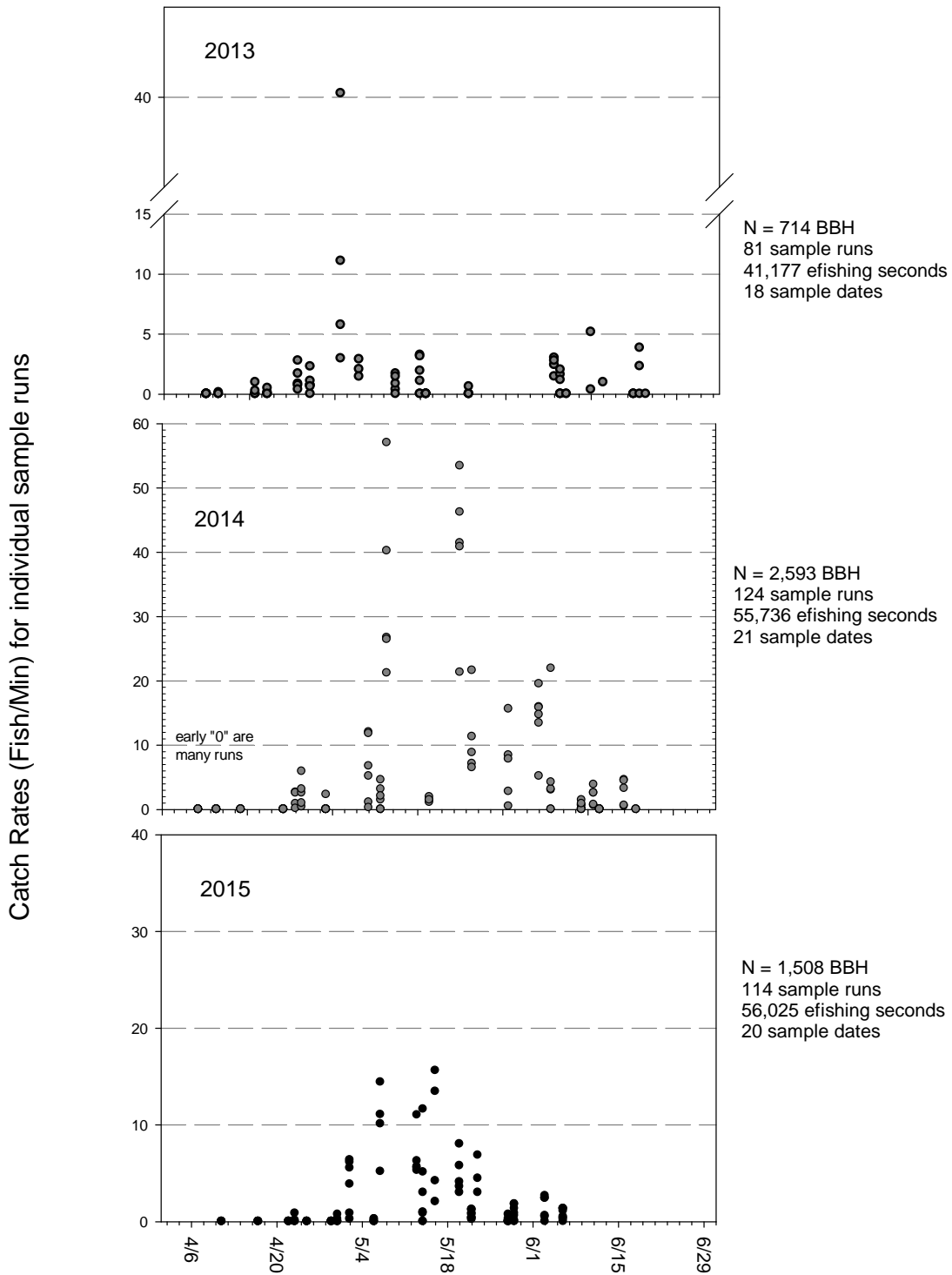


Figure 2. Blueback Herring catch rates from surveys 2013-2015, without reference to locations. Early season single point “zeros” are comprised of “many” runs with zero fish, 8-10 sample runs.

## **Appendix G. Connecticut Department of Energy and Environmental Protection River Herring Monitoring Programs**

**(David Ellis)**

### **Fish Counters**

Connecticut (CT DEEP) installed its first fish counter in Mill Brook in Old Lyme in 2002. Since then, it has added other counters at key locations. Currently, seven Smith-Root model 1601 counters are being used annually. Locations include: Mary Steube Fishway (Mill Brook, Old Lyme), Mianus Pond Fishway (Mianus River, Greenwich), Lower Guilford Lakes Fishway (East River, Guilford), Branford Water Supply Ponds Fishway (Queach Brook, Branford), Latimer Brook (Latimer Brook, East Lyme), Rogers Lake Fishway (Mill Brook, Old Lyme), and Bride Lake weir (Bride Brook, East Lyme). Only Alewife ascends Mill Brook, Latimer Brook, Queach Brook or Bride Brook. Both species of river herring ascend the Mianus Pond and Lower Guilford Lake fishways. The two species' runs can overlap so to distinguish counts of the two species, the run is sampled and collected fish are identified. The counts are assigned to species according to the ratio observed in the sample. The only significant change in design over the years has occurred at Latimer Brook. Originally this fishway was a trap and hand count design. However, increases in run size warranted the installation of an electronic fish counter. All of these fish counters are visited daily to clean the counting arrays and to download nightly counts. Counters are installed before run initiation each year and removed at the end of the run or as post spawn fish start to emigrate. Cumulative daily counts are used to generate a season total. Counts of river herring ascending selected fishways are compared to counts from previous years determine trends in run strength.

### **Fishway Window Counts**

CT DEEP began using video capture equipment to enhance the accuracy of counts at select fishways in 2001. Since then, eight video stations have been used to monitor and provide the total number of river herring passed at the fishways at Rainbow (Farmington River, Windsor), Kinneytown (Naugatuck River, Seymour), Greeneville (Shetucket River, Norwich), Bunnells Pond (Pequonnock River, Bridgeport), Moulson Pond (Eightmile River, Lyme), StanChem (Mattabesset River, Berlin), Harry Haakonsen (Quinnipiac River, Wallingford) and Hallville (Poquetanuck Brook, Preston) . A variety of camera styles is being used in combination with motion detection digital video capturing software. Overlapping runs of both species complicate the calculations. To address this concern, discrete seasons are defined by fixed calendar dates for each species for each region based on past observations. The use of these fixed seasons may result in over- or under- estimations of runs of both species due to erroneous presumption of species identification, but the imposed consistency will allow year-to-year comparisons without the burden of sampling every observed run on a daily basis. This fixed calendar method is sometimes augmented by species sampling during run overlap. Weekly sample ratios during run overlap are applied

to counts during that time period. Counts of river herring are compared to counts from previous years as an indication of run strength.

### **Observational Surveys**

Observational surveys were developed in 2002 to include monitoring river herring runs in streams that lack dams and fishways (which expedite data collection). These streamside observational surveys collect qualitative data that are then converted into numbers that can be used to generate quantitative data. Observations are made at one or more appropriate sites (holding or staging areas) per stream. Monitors estimate the abundance of river herring seen at each location using a rating system consisting of four score categories: 0= no fish; 1= low (<50 fish); 2= moderate (50-999 fish); 3= high (> 1,000 fish). Rating Scores for all days during the season are added for each stream to provide a season total Rating Score. An Estimate-Per-Unit-Effort (EPUE) is calculated for all streams by dividing the Rating Score by the number of daily checks that were made. A Presence Index is calculated for each stream by dividing the number of days the river herring species are observed in the stream by the number of days the stream was checked. EPUEs and Presence Index values are calculated for both species separately for each stream. Overlapping runs of both species complicate the calculations. To address this concern, discrete seasons are defined by fixed calendar dates for each species for each region based on past observations. The use of these fixed seasons may result in over- or under- estimations of runs of both species due to erroneous presumption of species identification, but the imposed consistency will allow year-to-year comparisons without the burden of sampling every observed run on a daily basis. Year-to-year comparisons were made using a T-test: two-sample assuming unequal variances with a 0.05 level of significance.

### **CT DEEP Juvenile Alosine Survey**

Juvenile American shad are collected weekly from mid-July through mid-October at seven fixed stations located from Holyoke, MA to Essex, CT in the Connecticut River. Seine haul locations and techniques have remained similar to those employed in past Connecticut River shad investigations (Marcy 1976; Crecco et al. 1981). Sites were previously chosen based on location, physical conditions and accessibility. One seine haul per station is made during daylight hours with a 15.2 m nylon bag seine (4.6 mm mesh, 2.4 m deep, and 2.4 m bag) and 0.5 m lead ropes. Each haul is completed by using a boat to set the net approximately 30 m upstream and offshore of the site. Using the lead ropes, the seine is then towed in a downstream arc to the shore and beached. With small sample sizes, all clupeids (*Alosa sapidissima*, *A. aestivalis*, *A. pseudoharengus*, and *Brevoortia tyrannus*) are stored in ice and returned to the laboratory. With large sample sizes, clupeids are subsampled volumetrically and unneeded fish returned to the water. Water temperature, weather conditions, time and tidal stage (when appropriate) were recorded for each station.

In the laboratory, juvenile clupeids are identified to species by the criteria of Lippson and Moran (1974) and counted. Up to 40 juvenile shad per haul are measured (TL mm). Individual seine collections containing greater than 40 shad are randomly subsampled for length measurements. All other clupeids

are only counted. The relative abundance of juvenile American shad are calculated as the geometric mean catch per seine haul from all stations and all dates sampled.

## **Appendix H. New York State Department of Environmental River Herring Monitoring Programs**

**(Robert Adams and Wes Eakin)**

### **NYS DEC River Herring Adult Spawning Stock Haul Seine Survey**

#### ***Survey Methods***

In 1987, the Hudson River Fisheries Unit added river herring sampling to the existing American shad and striped bass spawning stock survey. From 1987 to 1990, two small mesh (9.5 mm) beach seines (30.5 and 61m) were used with limited success. In 1998, the Unit specifically designed a small haul seine (91 m) with an appropriate mesh size (5.1 cm) to target river herring. Similar to the gear design for the American shad and striped bass seine survey, the Unit designed the herring seine to capture all sizes present with the least amount of bias (Kahnle et al 1988). The herring haul seine design consisted of two 46 m long by 3.7 m deep wings attached to a round, center-located bag measuring 1.2 meters in diameter and 3.7 m long. The entire net was 5.08 cm stretch mesh made of twisted nylon twine. The top float line included fixed foam floats every 0.6 m and fixed chains to the lead line (bottom of seine) every 0.75 m.

The objectives of the fishery independent haul seine survey were to evaluate species, size, sex composition, and age structure of spawning river herring; and then develop an annual relative abundance index of the Hudson River's river herring spawning stock. We set a sampling target of four sample days per week over 15 weeks (March 15 to June 15). We targeted a minimum of four beaches to be sampled each day.

The net is set by boat in the direction of the tide. One end of the net is landed and held on the beach, the net is deployed off the bow as the boat backs out. At the center point of the net, the boat is turned parallel to shore until the entire net is set. The upper end is moved in the direction of the tide to keep the lead line on the bottom, while the down-tide end is towed to shore by boat. The net is hauled to shore by hand, keeping the bag centered. The general shape of the area swept is an oblong ellipse, depending on prevailing current, winds, and waves.

Water quality data are taken at each sampling site. Parameters include temperature, salinity, pH, dissolved oxygen, conductivity and total dissolved solids.

#### ***Sampling Intensity***

Sampling occurred sporadically from 1987-2011 when time and staffing allowed. Since 2012, we have sampled four fixed stations in the Kingston, Catskill, and Coxsackie reaches and three fixed stations in the Albany reach totaling 15 fixed stations sampled per week. River reaches are freshwater tidal and include: Kingston (rkm 136-169), Catskill (rkm 170-190), Coxsackie (rkm191-213), and Albany (rkm 214-225) (Figure 1). We selected sections based on the time of year, relative location of the spawning run, weather, and tide stage. Within each section we selected fixed stations from a map of all known beaches

within the Hudson River Estuary. Stations were selected based on our abilities to deploy and retrieve the gear, prior sampling, and areas with known river herring spawning.

### ***Biological Sampling***

We examined each river herring for species, gender, and spawning condition. For each haul, we took a ten fish subsample of each gender and species and measured total length, weight, and obtained a scale sample. When possible, we measured total length for an additional 30 fish from each sex and species for each sampling event. All other incidental catch was tallied by species; we measured and removed scale samples from other important fishes (e.g. striped bass, smallmouth bass, etc).

### ***Development of Estimates***

In 2012 when sampling methods and efforts became consistent, we calculated the annual relative CPUE as a geometric mean of each species, and combined spawning adult river herring. In 2012, we also began production ageing of both species of river herring to determine age structure to calculate mortality estimates. Aging methods followed those developed by MA Division of Marine Fisheries. Prior to 2014, a minimum of 30 subsamples of fish were aged per 10 mm length bin. In 2014 and in the future, we will examine a subset of 10 fish per 10 mm length bin (Coggins et al 2013).

Our future objective is to develop total mortality benchmarks for the stock.

### **Tributary Sampling**

We are currently investigating the feasibility of monitoring spawning adult river herring in select tributaries of the Hudson River using resistivity counters (Smith Root® SR-1601). Results from a pilot study in Black Creek, one of the roughly 65 major Hudson River tributaries, are promising, however; the issue of potential double counting individuals needs to be addressed. We are currently analyzing tag data that uniquely identifies individuals passing through the resistivity counters which will allow us to estimate the rate at which double counting is occurring.

### **NYS DEC Young-of-Year Alosine Beach Seine Survey**

#### ***Survey Methods***

Since 1980, the NYSDEC has obtained an annual measure of relative abundance of young-of-the-year American Shad in the Hudson River Estuary. Although the program was designed to sample YOY American shad, it also provides data on the two river herring species. Gear is a 30.5 m by 3.1 m beach seine of 6.4 mm stretch mesh, with a deeper collection area, or bunt, in the center of the net. The bunt measures 6.1 m by 3.7 m. The entire seine, including the bunt, is constructed with 0.64 cm heavy delta (1/4 inch) bar mesh, with floats and a lead line.

The net is deployed by boat. One end of the net is landed and held on the beach while the boat backs out. The entire net is fed off the bow so that it is roughly perpendicular to shore. The river end is dragged to shore by the boat so that the net sweeps over the sample site. The net is then hauled to shore by

hand, starting at both ends so that the bag comes in last. The general shape of the area swept is an ellipse, depending on prevailing tide, winds, and waves.

### ***Sampling Intensity***

The Alosine Survey in the freshwater Hudson River Estuary has experienced many large scale changes in sampling since its initiation in 1980. Adjustments were made as biologists learned more about the temporal and spatial distribution of target species. For this reason, data from the earlier years is not always comparable. Changes are as follows:

- When initiated in 1980, a stratified random sampling regime was set up which seined the Hudson River from Rkm 38 to Rkm 245. This entire length of river is tidal and encompasses both brackish and freshwater reaches. Generally the salt front remains below rkm 90 during most of the year but can become brackish as far north as rkm 120 depending on freshwater flow and rain. The river was divided into eight river sections (strata) so that each section had equal surface area. Five seine sites were randomly selected from a pool of possible seine sites per river section for each sample week. This continued for 1981 and 1982; bi-weekly August through October.
- In 1983 sampling was revised in order to concentrate effort into those river sections which had higher catches (the more important nursery area) for American Shad, the target species; areas with zero catches were dropped (below rkm 90). A set of standard sites were selected from the total number of seinable sites in the river above rkm 90. This area was further subdivided into four standard sampling sections; they are Newburgh (rkm 71-108), Poughkeepsie (rkm 109-150), Coxsackie (rkm 188-209), and Albany (rkm 211-245). In 1983-1986, approximately 40 standard sites were sampled throughout these four areas during each sampling week.
- In 1985 sampling was initiated earlier in the season in order to encompass the timing of peak abundance of YOY Blueback Herring, American shad, Alewife, White Perch and Striped Bass. Three additional sites were added; sampling occurred bi-weekly from mid-June through October.
- In 1987 many of the sites were eliminated due to reoccurring problems with aquatic plants, such as water chestnut, and/or obstructions such as rocks which made the seining sites impossible to use during certain parts of the summer.
- In 1989, a major cut-back in funding required that sampling be reduced and stream-lined. Sites were eliminated based on lower catches of YOY American shad; 28 fixed sites were selected in the four sections described above. Sampling sites include six in Albany (rkm 216-225), nine in Coxsackie (rkm 195-208), five in Poughkeepsie (rkm 111-126) and eight in Newburgh (rkm 87-97). These sites have remained un-changed since 1989. Each section takes one day, requiring a four day sampling week. Sampling is done every other week from the end of June through the month of October and sometimes into November.
- All sampling throughout the time series has occurred during daytime.



- Water quality data are taken at each sampling site. Parameters include temperature, salinity, pH, dissolved oxygen, conductivity and total dissolved solids.

### ***Biological Sampling***

All fish collected are identified to species, life stage (YOY or other), counted and returned to the river. A subset of 30 YOY fish per seine haul of Blueback Herring, Alewife, American shad, Striped Bass, and White Perch are measured for total length (mm). Length, weight and scales are also taken from other important fish species, or those estimated to be over one year of age based on date of collection and relative size. Other species include, but are not limited to, Yellow Perch, Northern Pike, catfish species, and Black Bass (Largemouth & Smallmouth bass).

### ***Development of Estimates***

Catch per unit effort is expressed as annual geometric and arithmetic mean of number of fish per seine haul for annual weeks 26 through 42 (July through October), the period encompassing the major peak of use in the middle and upper estuary. Staff are currently investigating alternative methods for CPUE estimation, including adjusting timeframe for species-specific differences, as well as the inclusion of covariates such as tide stage, salinity, and water temperature.

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# **Appendix I. New Jersey Division of Fish and Wildlife River Herring Monitoring Programs**

**(Heather Corbett)**

## **NJ Striped Bass YOY Survey**

Since 1980, the New Jersey Department of Environmental Protection (NJDEP) has conducted a striped bass survey in the Delaware River to provide an annual index of striped bass juvenile abundance. Field sampling utilized a bagged, 100-foot long by 6-foot deep by ¼-inch mesh beach seine. All striped bass caught were quantified and measured. Basic water quality parameters that included water temperature, salinity and dissolved oxygen were also recorded.

By 1987, the survey evolved into a sampling scheme that consisted of sixteen fixed stations twice a month from mid-July through mid-November, with two seine hauls at each station during each event. This format was followed consistently from 1987–1990. After a thorough statistical analysis of the first ten years worth of data, the consulting firm, Versar Inc, provided a number of recommendations for the survey design. They included: a) sampling season from August through October; b) utilizing both fixed and random stations; c) concentrating fifty percent of the sampling effort to Region II; and d) eliminating replicate samples. These recommendations were incorporated into the sampling protocol from 1991–1997. A fixed station format was followed during the 1998-2015 seasons, where 32 stations were sampled twice a month from August through October. Occasionally due to tidal extremes, sediment or construction, alternate sites are sampled.

The Delaware River recruitment survey area is divided into three distinct habitats:

- 1) Region I -- brackish, tidal water extending from the springtime saltwater/freshwater interface to the Delaware Memorial Bridges
- 2) Region II -- brackish to fresh tidal water extending from the Delaware Memorial Bridges to the Schuylkill River at the Philadelphia Naval Yard, and
- 3) Region III -- tidal freshwater from Philadelphia to the fall line at Trenton

Regions I and II represent the historical striped bass spawning grounds. Saltmarsh vegetation predominates along the Region I shoreline while Region II is primarily urban with a shoreline heavily developed for commerce and industry. Region III is sporadically developed by industry with considerable freshwater marsh.

### *River herring*

All river herring are quantified and a minimum and maximum length (FL, mm) is recorded. Since 2002, a subsample of each species were measured.

A geometric mean for each species is calculated from August through October from Trenton to the Delaware Memorial Bridge only to avoid many of the zero catches in waters of higher salinity where river herring are less likely to be encountered.

### **NJ Ocean Trawl Survey**

The New Jersey Ocean Trawl Survey is a multispecies survey that started in August 1988 and samples the near shore waters from the entrance of New York Harbor south, to the entrance of the Delaware Bay five times a year (January, April, June, August and October). There are 15 strata with 5 strata assigned to 3 different depth regimes; inshore (3 to 5 fathoms), mid-shore (5 to 10 fathoms), and off-shore (10 to 15 fathoms). Station allocation and location is random and stratified by strata size.

The survey net is a two-seam trawl with forward netting of 4.7 inch stretch mesh and rear netting of 3.1 inches stretch mesh. The codend is 3.0 inches stretch mesh and is lined with a 0.25 inch bar mesh liner. Each trawl is 20 minutes long and at the end of each tow, the total weight of each species is measured in kg and the length of all individuals, or a representative sample by weight for large catches, is measured to the nearest cm. A series of water quality parameters, such as surface and bottom salinity, temperature and dissolved oxygen, are also recorded at the start of each tow.

### *River herring*

The majority of river herring are captured during the January and April trawls so only those months are used for the geometric mean for each species. New Jersey has been collecting otoliths and other biological data in 2009 to develop age at length keys for both species but the samples have not been completely processed at this time

### **Union Lake Fish Ladder (2013-2015)**

The Union Lake dam is the first impoundment along the Maurice River and a Denil style fish ladder was installed in the spillway during 1991. At the top of the fish ladder (right before the lake entrance) a flat trap is placed that allows water to flow through the fish ladder but prevents fish from entering the lake, approximately five feet in front of the flat trap is a “V” style trap that allows fish to funnel into the trap.

The fish ladder trap focusses on monitoring adult populations in the spring. The fish ladder is checked by staff three to four days a week. The trap is in place from March to the end of May. The dates of when the fish trap is in the ladder are adjusted from year to year due to the weather and start/ end of the River Herring run. River Herring are counted and measured by fork length (mm), total length (mm), sex, and ripeness. All other fish species in the trap are counted. Air temperature, water temperature, weather conditions, wind speed and direction, moon phase, percentage of cloud cover, and tide are also recorded.

### **Gill Net – Great Egg Harbor River (2015), Maurice River(2013-2015), and Rancocas Creek (2013-2014)**

Adult river herring moving into spawning areas are collected by use of anchored sinking gill nets that measured 141' x 6' x 3" and 171' x 6' x 3" stretch mesh in study areas. The longer net is only utilized further downstream in the Maurice River and Great Egg Harbor River in an attempt to collect Blueback Herring. The survey runs from March to June, but is adjusted from year to year due to the weather and start/ end of the River Herring run. Each river system is sampled once per week. Sets ranged from 90 to 120 minutes in duration and were made perpendicular to the shoreline whenever possible. River Herring are counted and measured by fork length (mm), total length (mm), sex, and inspected for ripeness. All other species are counted and a total length (mm) of the smallest and largest individual are recorded. Air temperature, water temperature, weather conditions, wind speed and direction, moon phase, percentage of cloud cover, and tide are also recorded.

### **Seine Net- Great Egg Harbor River (2015), Maurice River (2013-2015) and Rancocas Creek (2013-2014)**

Juvenile river herring are collected on all three river systems utilizing a 100' x 6' x ¼ mesh beach seine with a bag at fixed stations. Sampling is weekly begins in July and ends in October.

Fisheries data collected while beach seining is consistent with protocols utilized during the Bureau of Marine Fisheries' striped bass recruitment survey for the Delaware River. A total of 30 Alewife and Blueback Herring are subsampled from each haul and measured to fork length (mm). All remaining Alewife and Blueback were counted and released. All remaining non-target fishes are counted and a minimum and maximum range in size is recorded. Tide, weather, and wind speed and direction, cloud cover, and moon phase are recorded for the day and water temperature, air temperature, salinity and dissolved oxygen are recorded at each station.

### **Electrofishing – Rancocas Creek (2013-2014)**

An electrofishing boat is utilized on the north and south branches of Rancocas Creek due to the limited number of seining locations in these areas. Sampling via an 18-foot Smith and Root model E electrofishing boat is performed for a one hour interval and the start and end point is recorded with a handheld GPS unit. Depending on the tide, the boat was run into the current and all alosines observed are collected by two staff netting at the bow. All other fishes observed are not netted. Following the electrofishing interval, the catch of alosines is identified to species and counted and a 30 fish subsample for Alewife, Blueback Herring and American shad are measured to fork length (mm). All water chemistry including conductance and specific conductance are recorded.

## **Appendix J. Pennsylvania Fish and Boat Commission River Herring Monitoring Programs**

**(Josh Tryninewski)**

### **Adult Fish Passage Counts**

As required by FERC license agreements, owners operating the Conowingo (RM 10), Holtwood (RM 25), Safe Harbor (RM 33) and York Haven (RM 65) dams on the Susquehanna River are required to provide fish passage past their facilities. The primary objective of this survey is to document and characterize annual passage of adult American Shad, Alewife and Blueback Herring during their spring spawning migrations into the Susquehanna River. All work is accomplished by private consultants hired by individual facility owners, with oversight by the Susquehanna River Anadromous Fish Restoration Co-op (SAFRAC).

### ***Survey Methods***

Fish are passed over these dams by use of fish lifts (Conowingo, Holtwood and Safe Harbor) and a vertical slot fishway (York Haven). At fish lift facilities, upriver migrating fish are attracted to fishway entrances, crowded over a hopper bucket, lifted vertically from the tailrace elevation, dumped into an exit trough and allowed to swim into the river above the dam. Fish counts are made by trained biological observers at observation windows within the lift's exit trough to monitor fish passage in real-time. Real-time fish counts occur only during times of fish lift operation.

### ***Survey Intensity***

Fish lifts became operational in 1997 at Conowingo, Holtwood and Safe Harbor. The vertical slot fishway was operational at York Haven in 2000. Generally, fish lift operations initiate on 1 April through 30 June, dependent on water temperature triggers set by SAFRAC. Each lift is only operated during daytime hours.

### ***Biological Sampling***

The first 50 adult herring of each species are collected and harvested for biological characteristics. Collections are only conducted at the river's gateway dam (Conowingo) via the West Fish Lift which operates as a trap (not a lift for passage). After the first 50 of each adult herring species are collected, one of every 25 additional specimens are collected and sacrificed. Biological parameters collected include total length, gender, and total weight. Scales and otoliths are also taken for age determination, repeat spawning frequency and hatchery origin determination.

### ***Biases***

Landlocked populations of Alewives are present in Susquehanna River Basin impoundments and some of those recorded at the fishways may not be anadromous in origin. Sampling constrained to observation room, during times targeted for direct observation.

### ***Development of Estimates***

Abundance is expressed as the total passage counts, specific to each facility.

### **YOY Beach Seine**

Annual beach seine sampling is accomplished, by private consultants, contracted through PA Fish and Boat Commission. The primary objective is to document annual year-class successes of American Shad, Alewife and Blueback Herring in the Susquehanna River.

### ***Survey Methods***

Sampling of fishes occurs using a 400-ft x 6-ft x 3/8-in mesh bagless seine. Two fixed stations including, Columbia (RM 43) and City Island (RM 71) are sampled once a week, July through October, over a 15 week period. A total of six (6) non-overlapping hauls are accomplished in the vicinity of each fixed station. All sampling is conducted during nighttime hours, beginning approximately one hour after sunset. All fish are identified to the lowest taxonomical level and enumerated by species. Water temperature (°C), mean daily river flow (cfs), and water clarity (secchi depth) are recorded prior to each sampling effort.

### ***Survey Intensity***

At the Columbia station, seining was initiated in 1989 and continues through present date. Seining at the City Island site was initiated in 2010 in response to losing a long-term lift net sampling location in the forebay of the Holtwood Dam. Seining at the City Island station was subsequently discontinued in 2014 due to funding constraints.

### ***Biological Sampling***

When available, the first 30 of each American Shad, Alewife and Blueback Herring collected on a sampling date were harvested, measured to the nearest millimeter total length and retained for otolith analysis (determination of origin, wild vs hatchery). All other fish collected (including any additional Alosines) were identified to lowest taxonomic level and enumerated.

### ***Biases***

During the initial years of the survey, 1989-2001, at the Columbia site, American Shad were regularly captured in moderate to high numbers. Between 2002 and present date, American Shad catch has been very low to absent. No Blueback Herring and very few Alewife were captured at the Columbia station while neither species was collected at the City Island station. Juvenile river herring remain

consistently absent from Columbia and City Island seining collections, presumably a result of no to very few adults passing above Safe Harbor dam.

### ***Development of Estimates***

Annual relative abundance is calculated as a geometric mean of total catch for the year, from all hauls at both fixed stations.

### **Biological YOY Sampling at Holtwood Dam Forebay**

Annual lift net sampling from the forebay of Holtwood Dam was accomplished, by private consultants, contracted through PA Fish and Boat Commission. The primary objective was to document and characterize annual year-class successes of juvenile/young-of-year American Shad, Alewife and Blueback Herring in the Susquehanna River.

### ***Survey Methods***

Sampling for fishes occurred using a 8-ft x 8-ft x 0.5-in stretch mesh lift net, with an inner 0.25-in stretch mesh liner. A 13-inch diameter 5-gallon bucket nested in the center of the lift net could be pulled up independently from the lift net to remove fish that funneled into the bucket. A total of ten lifts were accomplished, beginning one hour prior to sunset and ending one hour after sunset. All fish caught were identified to the lowest taxonomical level and enumerated by species.

### ***Survey Intensity***

Lift netting surveys were typically conducted August through December, 1985 - 2009. Sampling occurred once a week, during nighttime hours. Attraction of American Shad and river herring to the lift net was accomplished by shinning a lighting system directly over the net.

This program was discontinued in 2009 due to the re-development of the Holtwood Dam hydroelectric facility. Reconstruction eliminated any ability for continued operation of lift net sampling.

### ***Biological Sampling***

Throughout the years of lift netting at the Holtwood Dam, very few river herring were collected. A small number of Alewife were collected in the early 2000s, however, they were thought to be strays from several inland reservoirs which have self-sustaining, non-migratory Alewife populations.

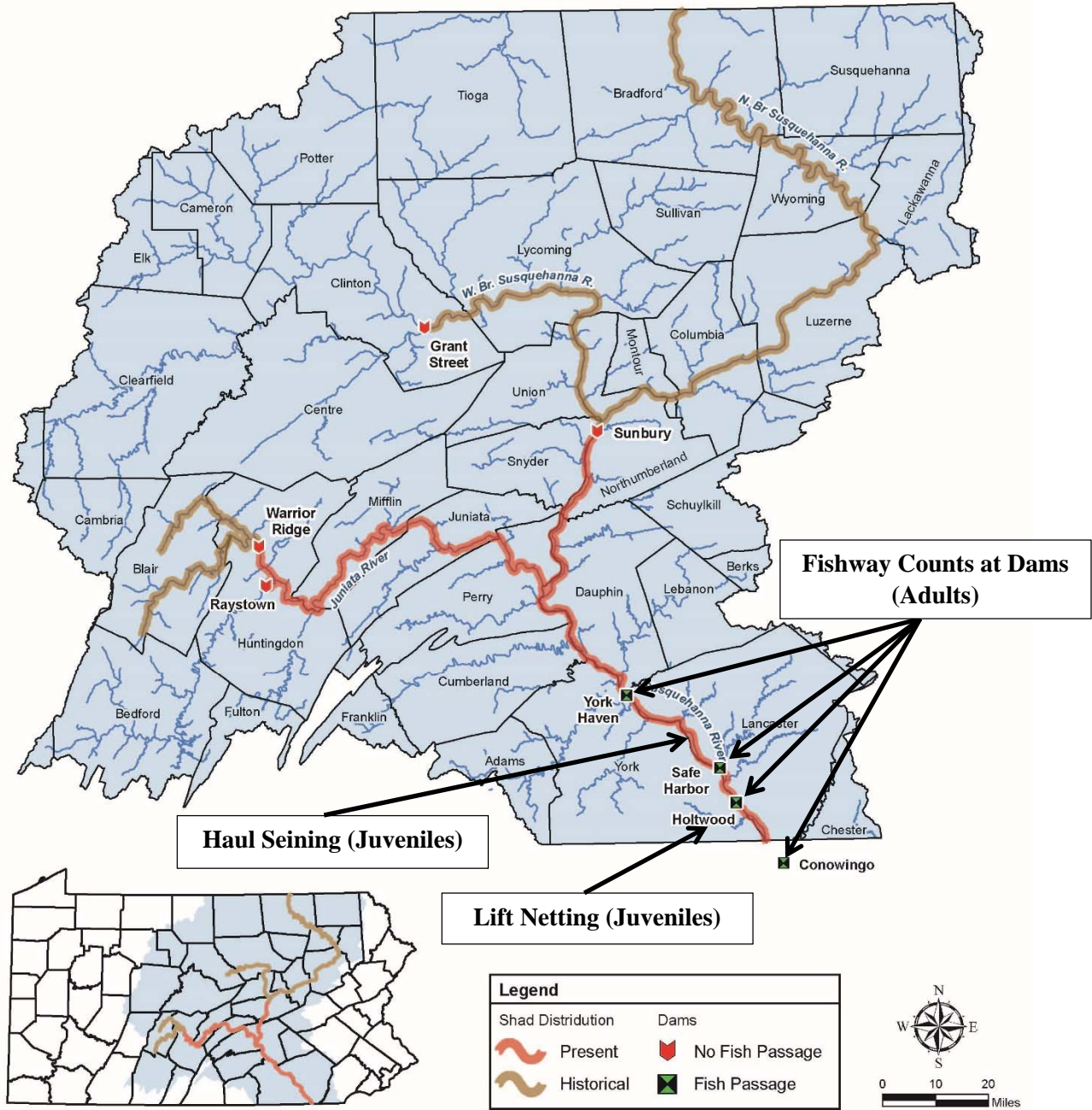
### ***Biases***

Landlocked populations of Alewives are present in Susquehanna River Basin impoundments and some of those recorded at the fishways may not be anadromous in origin.

### ***Development of Estimates***

Relative abundance was expressed as a geometric mean of all catch per unit of effort (fish per haul) for each year.

# American Shad Habitat and Distribution Susquehanna River Basin Pennsylvania





## **Appendix K. Delaware River Fish and Wildlife Management Co-operative River Herring Monitoring Programs (Daryl Pierce)**

The four states bordering the Delaware River: Pennsylvania, New Jersey, Delaware and New York, collectively with the US Fish and Wildlife Service and National Marine Fisheries Service comprise the Delaware River Basin Fish and Wildlife Management Cooperative (Co-op). The National Park Service and Delaware River Basin Commission provide liaisons to the Co-op, but are not voting members. The Philadelphia Water Department also contributes resources to Co-op activities. The objective is mutual management of fish stocks within the river basin.

### **Delaware River YOY Non-tidal Beach Seine Survey**

The Co-op conducts a young-of-the-year American Shad beach seine survey in the non-tidal reaches of the Delaware River, since 2012 to present. The primary objective of this survey is to document annual year-class success of YOY American Shad, Alewife, and Blueback Herring, above the tidal fall line at Trenton, NJ. This survey was the re-initiation of New Jersey's Division of Fish and Wildlife (NJDFW) historical monitoring efforts from 1979–2007.

### ***Survey Methods***

Sampling of fishes occurs using a 300-ft x 12-ft x 0.25-in mesh (delta knotless) bagless beach seine. A total of four fixed stations including, Trenton (RM 132), Phillipsburg (RM 183), Water Gap (RM 210), and Milford (RM 246) are sampled once per month, August through October. A total of four hauls are accomplished at each site, beginning at official sunset. Successive hauls are usually at thirty minute intervals. The initiation of a thirty minute interval begins when the previous net set is fully retrieved. All captured fishes are retained in live cars and released after the last haul for the night. Water temperature (°C) is recorded at the time of the first net set at each station. River flow (cfs) and stage (ft) conditions are obtained from the nearest USGS gage station.

### ***Survey Intensity***

Beginning in 1987, sampling occurred once a month, August through October at the four historic sites (i.e., Trenton, Phillipsburg, Water Gap, and Milford). Sampling was discontinued by NJDFW from 2008 through 2011. Beginning 2012 to present, the Co-op accomplishes sampling at the four historic sites, following the same protocols as per NJDFW historic sampling.

In 2015, four additional fixed station sites located further upriver are being evaluated. Two were in the Delaware River located at Skinners Falls (RM 295), Buckingham (RM 325); one was located in the West Branch Delaware River at Balls Eddy (RM 4.6); one was located in the East Branch Delaware River at Fireman's Launch (RM 0.2). The intent was to identify additional potential long-term fixed-station monitoring sites located in the upper reaches of the Delaware River. Fixed stations were identified based on access and suitable substrate for seining.

Prior to 2008, the NJDFW consistently sampled the Trenton, Phillipsburg, Water Gap, and Milford sites since 1987 through 2007. Alternative fixed stations were also sampled for various time periods, but of limited time-series.

### ***Biological Sampling***

All target fishes including American Shad, Alewife, and Blueback Herring, were enumerated for each net set. A representative sample of 25 individuals per species from each net set was measured to nearest 1 mm fork length. Other gamefishes were treated similarly as the target fishes, excepting measured to nearest 1 mm total length. Forage fishes are noted for presence/absence by species and are not measured for length frequencies. All fishes are only field identified to species or genus. Occasionally representative samples are returned for laboratory confirmation of species identification.

### ***Biases***

Original reasoning for initial survey design (gear type, timing and effort) is unknown. Station sites are limited by access and suitable substrate for seining. Assume 30 minute duration suitable to allow river herring to repopulate the seine swept area from those previously captured.

### ***Development of Estimates***

The four historic sites, Trenton, Phillipsburg, Water Gap, and Milford were the most consistently sampled (1987 – 2007; 2012 – present) over the complete time-series (1979-2007; 2012 – present). Relative abundance is calculated as a geometric mean of total catch for the year, from all hauls at the four historic sites.

### **Co-op funded Lewis haul seine**

The Lewis haul seine represents a significant time-series of landings for American Shad, beginning before the turn of the 20<sup>th</sup> century and continuing to present date. Annual record keeping for American Shad landings, however, became reliable by 1925. No records of river herring were historically kept, but the fishery was known to land considerable amounts of river herring, most notably in the 1980s.

Since 2008, basin state members of the Delaware River Basin Fish and Wildlife Management Cooperative (Co-op) individually contract the Lewis haul seine for monitoring American Shad annual spring spawning run. Each basin state is responsible for \$1,500 totaling \$6000 per year. The hiring of Lewis haul seine is on an *ad hoc* basis, dependent by each states' ability to separately provide their share of the cost. The primary objective of this effort is to provide an estimate of the American Shad spawning run into the non-tidal reach of the Delaware River. As per annual Scope of Services obligations, the Lewis haul seine is also responsible for enumerating river herring total catches.

### ***Survey Methods***

Scope of Services is annually submitted to the Lewis haul seine governing the general sampling regime. The intent is to provide some standardization of sampling timing to encompass the entire spawning run, but allow flexibility to ensure consistent sampling as per historic protocols.

As per Scope of Services:

- The seine will be deployed from a non-motorized boat as done in the past.
- A 200-yd. x 10-ft. x 3.5-in mesh seine will be used for all samples throughout the study period when flows allow. The net may be altered as needed during other flow regimes. Changes should be noted in daily sampling records.
- At least one seine haul will be conducted per day scheduled; additional hauls can be made at the Contractor's discretion.
- Starting time should be standardized relative to the predicted sunset (to the extent possible) on scheduled sampling days i.e. 1 hour before sunset.
- The area swept during each seine haul shall be approximately the same distance and occur in approximately the same location of the river.
- All biological data shall be collected by Lewis haul seine for each seine haul including the total number of species caught separated by species.

### ***Survey Intensity***

As per Scope of Services:

- Sample frequency will be three days per week (Monday, Wednesday and Friday) throughout the season beginning approximately the third week of March extending through May 31. The total number of days sampled should be approximately 30.
- If a scheduled sample is cancelled due to bad weather or high river flow periods, the next sample will be scheduled as soon as possible and the sample schedule shall be resumed consistent with the above sample frequency.

### ***Biological Sampling***

As per Scope of Services:

- All shad taken in the each haul will be counted by sex (if known). Any shad kept for market sale shall be recorded on the data sheet along with the appropriate biological information and for each fish. All other shad shall be returned to the water as quickly as possible following a caudal fin clip applied prior to release.
- All shad kept for market will be sampled for total length, total weight, sex, and scale sample. The scale sample should be taken from the fishes side below the dorsal fin located mid-body just above the color change from silver to green.
- Water temperature will be recorded each day hauled using a thermometer.
- All other anadromous species taken in each haul will be counted and recorded. Species include: river herring (Blueback Herring and Alewife), hickory shad, striped bass, shortnose and Atlantic sturgeon, and gizzard shad.

***Biases***

While the Scope of Services provides some standardization of sampling, sampling effort is dictated by river conditions. Shorter length seines are used generally in early spring, under high flows. As flows decline longer seines are employed. Thus, the total area swept is not consistent throughout the sampling period. Historically, mesh size was increased dependent if river herring were becoming gilled in the seine. Under the Co-op Scope of Services, mesh size is held constant to ensure collection of river herring. Alewife and Blueback Herring are reported as a collective total as river herring.

***Development of Estimates***

Relative abundance is calculated a catch per haul for all samples in a given year as combined species for river herring.

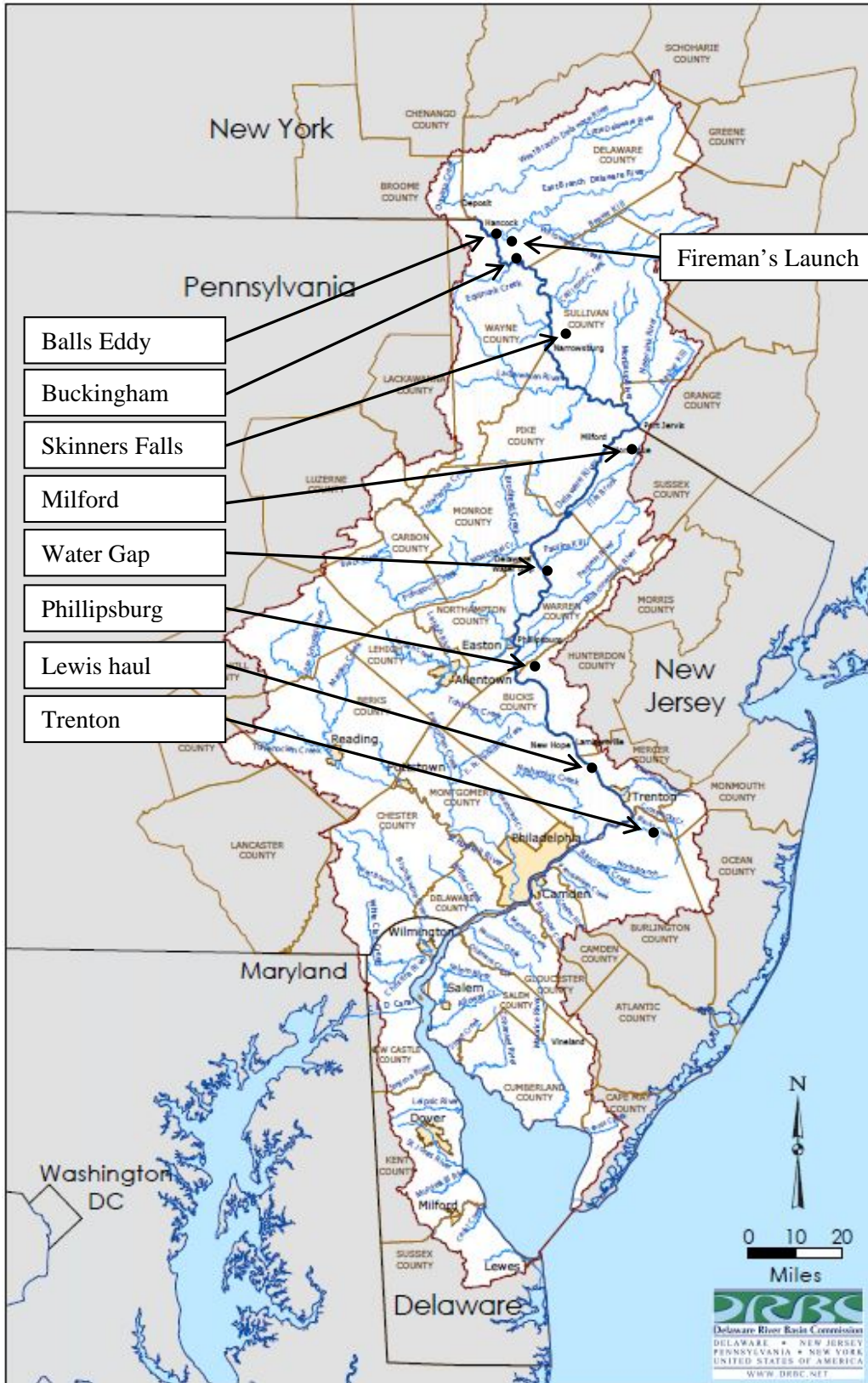


Figure 1. Sampling locations for the Delaware River YOY Non-tidal beach Seine Survey

## **Appendix L. Delaware Division of Fish and Wildlife River Herring Monitoring Programs**

**(John Moore)**

### **Delaware Estuary Trawl Survey**

The State of Delaware has conducted a trawl survey in the tidal reaches of the Delaware River and Bay since 1980 to present. The primary objective of this survey is to document annual species abundance.

#### ***Survey Methods***

Sampling occurs using a 16-ft otter trawl with 1.5-in stretch mesh in body and 0.5 – in stretch mesh in the liner. At least 38 fixed stations are sampled once per month, April through October. The otter trawl is towed once at each station for 10 minutes. All captured species are enumerated and released back into the environment. Water temperature, depth, DO, salinity, weather, and tide are recorded at each station.

#### ***Survey Intensity***

Since 1980 sampling has occurred at each fixed station once a month from April through October.

#### ***Biological Sampling***

All captured species are enumerated for each station. For almost all species, a representative sample of 30 individuals from each station is measured to the nearest 5 mm fork length. Hogchokers, anchovies, stingrays, and skates are counted by species and are not measured for length frequencies. All individuals are only field identified to species or genus. Occasionally representative samples are returned for laboratory confirmation of species identification.

#### ***Biases***

Station sites are fixed and not random.

#### ***Development of Estimates***

The fixed stations have been sampled relatively consistently since 1980. Relative species abundance is calculated by total catch per tow for the year, from the fixed stations.

### **Delaware Adult Trawl Survey**

The State of Delaware has conducted a trawl survey in the Delaware Bay from 1966 – 1971, 1979 – 1984, and 1990 to present. The primary objective of this survey is to document annual species abundance.

### ***Survey Methods***

Sampling occurs using a 30-ft otter trawl with 3-in stretch mesh in body and 2 – in stretch mesh in the cod. A total of 50 fixed stations are sampled once per month, March through December. The otter trawl is towed once at each station for 20 minutes. All captured species are enumerated and released back into the environment. Water temperature, depth, DO, salinity, weather, and tide are recorded at each station.

### ***Survey Intensity***

Sampling occurs at each fixed station once a month from March through December.

### ***Biological Sampling***

All captured species are enumerated for each station. For almost all species, a representative sample of 30 individuals from each station is measured to the nearest 5 mm fork length. Hogchokers, anchovies, stingrays, and skates are counted by species and are not measured for length frequencies. All individuals are only field identified to species or genus. Occasionally representative samples are returned for laboratory confirmation of species identification.

### ***Biases***

Station sites are fixed and not random.

### ***Development of Estimates***

The fixed stations have been sampled relatively consistently since 1990. Relative species abundance is calculated by total catch per nautical mile for the year, from the fixed stations.

### **Juvenile Abundance Index Survey**

The State of Delaware has conducted a juvenile abundance index survey in the Delaware portions of the Nanticoke River since 1999 to present. The primary objective of this survey is to assess reproduction and recruitment of Blueback Herring, Alewife, American Shad, and Hickory Shad.

### ***Survey Methods***

Sampling occurs using a 150-ft x 10-ft x 0.25-in mesh bagless haul seine. A total of four fixed stations are sampled once per month, July through October. All captured species are enumerated and released back into the environment. Water temperature, DO, salinity, and tide are recorded at each station.

### ***Survey Intensity***

Since 1999 sampling has occurred at each fixed station once a month from July through October.

### ***Biological Sampling***

All captured species are enumerated for each station. For Alosine species, a representative sample of at most 90 individuals from each station is measured to the nearest 1 mm total length. All individuals are only field identified to species or genus. Occasionally representative samples are returned for laboratory confirmation of species identification.

***Biases***

Station sites are fixed and not random.

***Development of Estimates***

The fixed stations have been sampled relatively consistently since 1999. Relative species abundance is calculated as a geometric mean of total catch per haul seine for the year, from the fixed stations.



## **Appendix M. Maryland Department of Natural Resources River Herring Monitoring Programs**

**(Genine Lipkey)**

### **MD DNR North East River Gill Net Survey**

Maryland DNR Fisheries Service Chesapeake Finfish Program conducted a gill net survey targeting river herring in the North East River from 2013 – 2015. This survey intends to assess trends in stock status of Alewife and Blueback Herring in the Upper Chesapeake Bay and provide biological data to characterize the stock and inform mortality estimates as required by ASMFC in Amendment 3 to the Shad and River Herring FMP. This survey was initiated after the last river herring stock assessment.

#### ***Survey Methods***

A multi-panel experimental anchored sinking gill net is deployed from a 25 foot outboard boat in the North East River weekly at four randomly chosen sites for 10 weeks from mid-March to mid-May. Sampling locations are randomly assigned each week from a grid superimposed on a map of the system (Figure 1). The grid consists of 112, 0.04 square mile quadrants. Sampling sites are subsequently randomized for depth, to determine if the net will be set in shallow or deeper water within the quadrant. Four alternate sites are also randomly chosen and used in cases where the chosen site is unable to be sampled. If depth is below 6 feet in a given site (4 feet on the depth finder, given the position of the transducer), the next available alternate site is selected.

Individual net panels are 100 feet long and 6 feet deep. The panels are constructed of 0.33 mm diameter monofilament twine in 2.5, 2.75 and 3 inch stretch mesh. In 2015, the 3" mesh panel was replaced with a 2 ¼" mesh panel, as there was evidence the current mesh size selection was not successful in capturing smaller sized Blueback Herring. The net has a 1/2 - 3/8 inch poly foamcore float line and a 50 pound lead line. Nets are hung with 200 feet of stretch netting for every 100 feet of net.

The three panels are tied together to fish simultaneously and are soaked for 30 minutes before retrieval. Panel order is randomly chosen before the net is tied together at the start of the survey. Two nets are assembled annually and routine maintenance to mend holes in the net is conducted throughout the sampling season. The net is deployed perpendicular to the channel from the bow of the boat. Deployment of the net takes approximately 1 to 2 minutes. Start and stop time for deployment is noted.

Following deployment of the net, surface water temperature, salinity, specific conductivity, turbidity, depth, tidal stage, and time of day are noted.

#### ***Biological Sampling***

All fish were identified and enumerated to species per gill net mesh size. All Alewife and Blueback Herring were sexed and measured to the nearest mm FL and TL. Scales were taken from a subsample of Alewife and Blueback Herring per panel (i.e. first 20 fish encountered of each species per panel) to determine age and spawning history. An annual cap of 300 scale samples per species was set beginning in 2015. In 2015 this cap was reached by the 6<sup>th</sup> and 8<sup>th</sup> week of the survey for Alewife and Blueback, respectively.

In 2013, fin clips were taken from Alewife and Blueback Herring and were sent to Duke University for genetic analysis. Fin clips have not been taken by this survey since 2013.

Scales are removed with a knife from the mid-lateral area just below the dorsal fin on the left side. A minimum of four scales per sample were cleaned, mounted between two glass slides and read for age and spawning history using a Bell and Howell MT-609 microfiche reader. The scale edge was counted as a year-mark due to the assumption that each fish had completed a full year's growth at the time of capture. Ages were not assigned to regenerated scales or to scales that were difficult to read.

A majority of the Alewife were caught in the 2 ½" mesh in all years. Alewife ranged in age from 3-8 and in size from 201-310 mm FL. A majority of the Blueback were caught in the 2 ½" mesh prior to the addition of the 2 ¼" mesh, which caught a majority of the Blueback in 2015. Blueback ranged in age from 3-7 and in size from 208-270 mm FL.

### ***Development of Estimates***

Catch-per-unit-effort (CPUE) was estimated separately for Alewife and Blueback Herring using catch from the 2 ½" and 2 ¾" mesh panels, as these two panels were sampled in all years (Figure 2). Alewife CPUE was calculated using the catch and effort data from the first 8 weeks of the survey, as the run typically tails off in early May. Conversely, the last 6 weeks of catch and effort data were used to calculate the Blueback CPUE, since the run does not typically begin until early April. Catch was pooled across all mesh sizes and CPUE is reported as the number of fish caught per set of experimental gill net per hour fished.

### ***Qualitative assessment***

The North East River Gill Net Survey is successful in capturing a relative sample of both Alewife and Blueback Herring spawning stock in the North East River. This survey captures the weekly temporal differences in these species spawning runs, and provides a relative index of abundance. Currently, the applicability of this survey is limited by the short time series. The ability to increase the temporal resolution of this survey is limited by cost and available man-power.

### **MD DNR Striped Bass Seine Survey**

Maryland DNR Fisheries Service Striped Bass Program conducted a statewide Striped Bass Juvenile Seine Survey from 1954–2015. The primary objective of this survey is to document annual year-class success of young-of-year striped bass. All fish species, including Alewife and Blueback Herring, are enumerated at each sampling station. This survey was used in the last stock assessment for river herring.

### ***Survey Methods***

Since 1954, MDNR has conducted a beach seine survey in July - September that samples 22 fixed stations within Maryland's portion of the Chesapeake Bay (Figure 3). From 1954 to 1961, the juvenile survey included inconsistent stations and timing, with each station generally being sampled once per year. In 1962 stations were standardized and were sampled twice a year. In 1966, a third sampling round was added for each station. Sites are sampled monthly with replicate seine hauls, a minimum of thirty

minutes apart. A 30.5 m x 1.24 m bagless beach seine of untreated 6.4 mm bar mesh is used. The area swept is equivalent to a 729 m<sup>2</sup> quadrant when the net is fully deployed. When depths of 1.6m or greater were encountered, the offshore end was deployed along this depth contour, and an estimate of the distance from the beach recorded. The environmental data that was collected include, weather, wind speed, tidal stage, salinity, maximum depth, SAV coverage, substrate, conductivity, pH, dissolved oxygen, turbidity, and water temperature.

Incidence rate and abundance of Alewife and Blueback Herring is variable throughout the time series, but both species have been encountered in every year of the survey (Figures 4 and 5). Annual catch of Blueback was greater than the annual catch of Alewife 91% of the time. On average Alewife have been captured at 50% of stations yearly, and Blueback have been captured at 55% of stations yearly (1966-2014).

### ***Biological Sampling***

A random sample of 30 individuals of select species are measured (mm TL), including Alewife and Blueback Herring (added in 1959). All other species are identified and enumerated. Alewife encountered by this survey ranged in size from 33 – 290 mm TL. Blueback encountered by this survey ranged in size from 20 – 292 mm TL.

### ***Development of Estimates***

The Bay-wide annual index by species is a geometric mean catch per haul calculated as the  $\log_e(x+1)$  transformation, where x is the individual seine haul catch. Indices derived from 1959-1961 only include stations which are consistent with subsequent years. Relative abundance is variable for both species across the time series with no significant trend. Indices for each of the tributaries sampled are also calculated separate from the Bay-wide index.

### ***Qualitative assessment***

Site selection for fixed stations was not random, but rather based on four major spawning and nursery areas for striped bass, which included the Head of the Chesapeake Bay, Potomac, Nanticoke, and Choptank rivers.

### **MD DNR Spring Pound and Fyke Net Survey**

Maryland DNR Fisheries Service Chesapeake Finfish Program conducted a fishery-dependent survey in the Nanticoke River between Vienna, MD and Rewastico Creek from 1989 – 2014. Prior to the closure of the river herring fishery in January 2012, a pound and fyke net bycatch fishery existed in some Chesapeake Bay tributaries like the Nanticoke River. Biologists were able to work with commercial fishermen to collect stock composition data and estimate relative abundance of adult American shad, hickory shad, river herring, white perch, yellow perch and catfish. This survey was utilized in the last river herring stock assessment.

### ***Sampling Intensity***

Sampling occurs in the Nanticoke River from late February to early May at a minimum of once a week, typically utilizing 1-2 commercial pound nets and 4-10 fyke nets, determined by the cooperating commercial watermen. Figure 6 shows the location of the nets fished in 2014. The commercial fishermen set all nets sampled as part of their regular fishing activity. Net soak time and manner in which they were fished were consistent with the fisherman's day-to-day operations. The mean net soak time for 1996 - 2014 was  $3.89 \pm 1.33$  days, ranging from 0.5 - 13 days.

### ***Biological Sampling***

A minimum of ten Alewife and ten Blueback Herring selected at random from unculled commercial catches were counted, sexed, fork length and total length measured to the nearest mm, and scales removed for age and spawning mark analysis. Prior to the closure of the river herring fishery the total number of herring harvested was estimated by multiplying the number of bushels harvested by the number of fish per bushel from sampled nets on that particular day or by direct counts. Since 2012, all river herring captured by the gear were enumerated by species and sex before they were returned to the water. In 2013, fin clips were taken from Alewife and Blueback Herring and were sent to Duke University for genetic analysis. Fin clips have not been taken by this survey since 2013. Otoliths were taken in 2013 to provide paired otolith/scale samples for the River Herring Ageing Workshop. In order to sample efficiently, and avoid hindering the watermen's work, whole fish are often brought back to the office on ice for biological sample processing, which allows for a subsample of Alewife and Blueback Herring to be weighed.

Across the time series Alewife have ranged in age from 2 – 9 and in size from 171 – 296 mm FL. Similarly Blueback have ranged in age from 2 -11 and in size from 193 – 293 mm FL. Both Alewife and Blueback age structure in the Nanticoke River appear to be truncating; evident by a decrease in the percent of Alewife and Blueback ages 6 and older in recent years. Blueback Herring mean length has significantly decreased across the time series (1989 – 2014;  $r^2 = 0.73$ ,  $P < 0.001$ ).

### ***Development of Estimates***

Relative abundance, measured as annual CPUE for Alewife and Blueback Herring collected from fyke nets in the Nanticoke River, was calculated as the geometric mean (based on a loge-transformation) of fish caught per net day. Only catch from fyke nets were included in the index calculation because pound nets were not generally set in the appropriate habitat for river herring.

The GM CPUE for Nanticoke River Alewife herring captured in fyke nets has significantly decreased over the time series (1990-2014;  $r^2 = 0.18$ ,  $P = 0.04$ ; Figure 7). The GM CPUE for Blueback Herring has also significantly declined over the time series (1989-2014;  $r^2 = 0.62$ ,  $P < 0.001$ ; Figure 7).

### ***Qualitative assessment***

The number and location of pound and fyke nets has varied throughout the time series based on the commercial watermen's fishing activity. Due to this variability, there are years (e.g. 2012) where no index

could be calculated because no fyke nets were set. Comparison of indices from year to year may not be a true comparison with the variability introduced by this sampling scheme. This survey does, however, sample Alewife and Blueback of all ages and a wide range of sizes.

### **Conowingo Dam Fish Lift Counts**

At the Conowingo Dam on the Susquehanna River there are two lifts (west and east) operated by Normandeau for the power company, Exelon, where fish counts are conducted annually by species. The East Fish Lift (EFL) is a flow through system and fish are counted at a viewing window, whereas the West Fish Lift (WFL) is a trap system where fish can be handled for counts and biological data. Run counts for Alewife and Blueback Herring at the East Fish Lift are available from 1991-2015.

### ***Sampling Intensity***

The two fish lifts are operated each spring during mid-April to early June. The WFL at Conowingo Dam has been used to monitor adult abundance since 1972. This lift operates in the traditional manner except that fish collected are dumped into a large steel trough where the catch is hand sorted by biologists. Target species are enumerated, sampled and then released back into the Conowingo Dam tailrace, used for tank-spawning, or transported upstream, as dictated by restoration plan requirements. The Conowingo EFL is constructed with a viewing window where a trained biologist counts all fish species as they exit the fishway and enter the upstream reservoir. This lift has been operating since 1991 but prior to 1997, fish were manually trucked upriver. It is also worth noting that flows have been increased since the late 1990's to maximize American shad catches in the east lift, which may decrease river herring catches.

### ***Qualitative assessment***

The lifts are operated to give priority to American shad passage and may exclude other species, including river herring. Since lifting is not initiated until April, a portion, if not all of the Alewife run is likely missed.

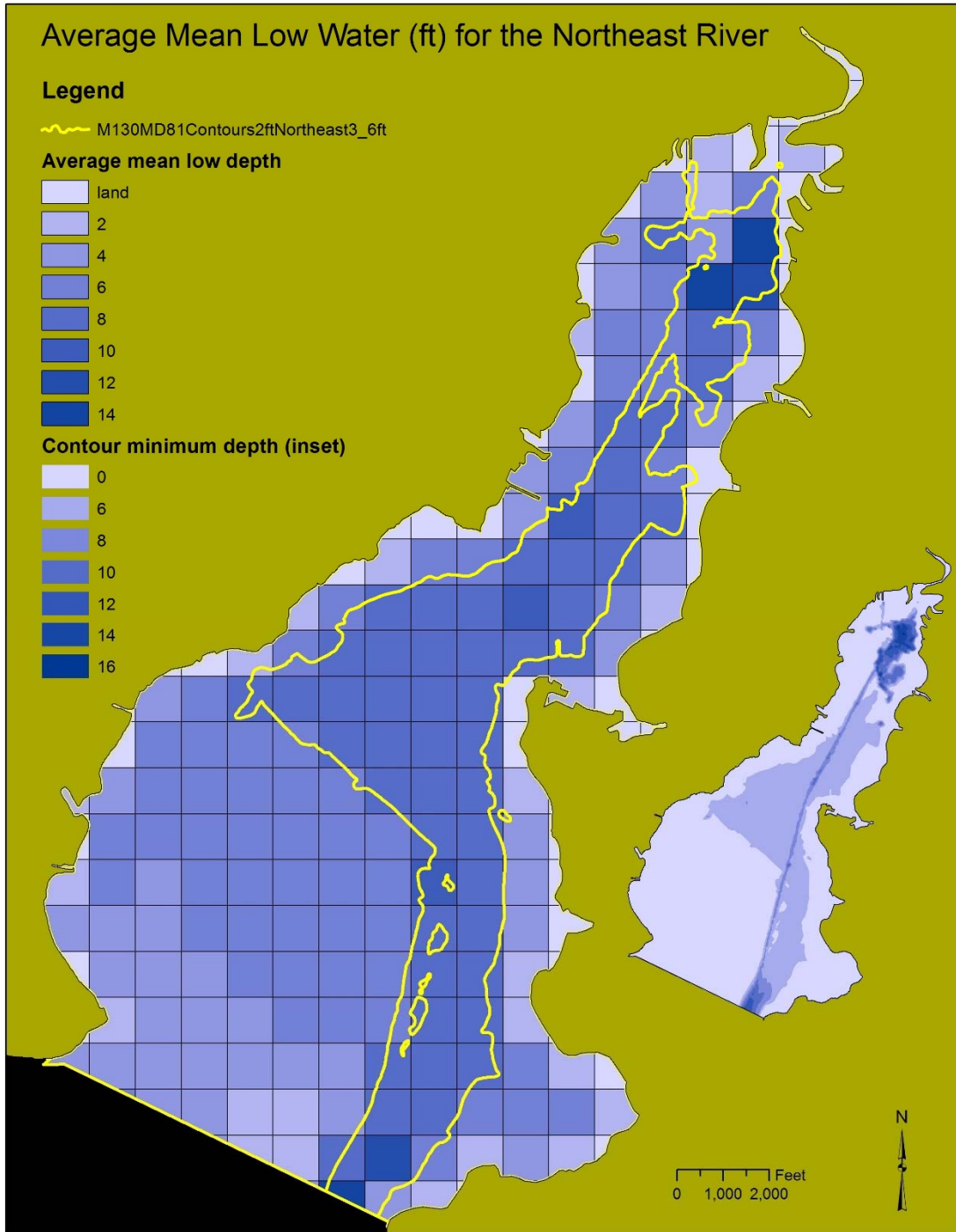


Figure 1. Grid from which sites are randomly chosen for the North East River sinking gill net survey.

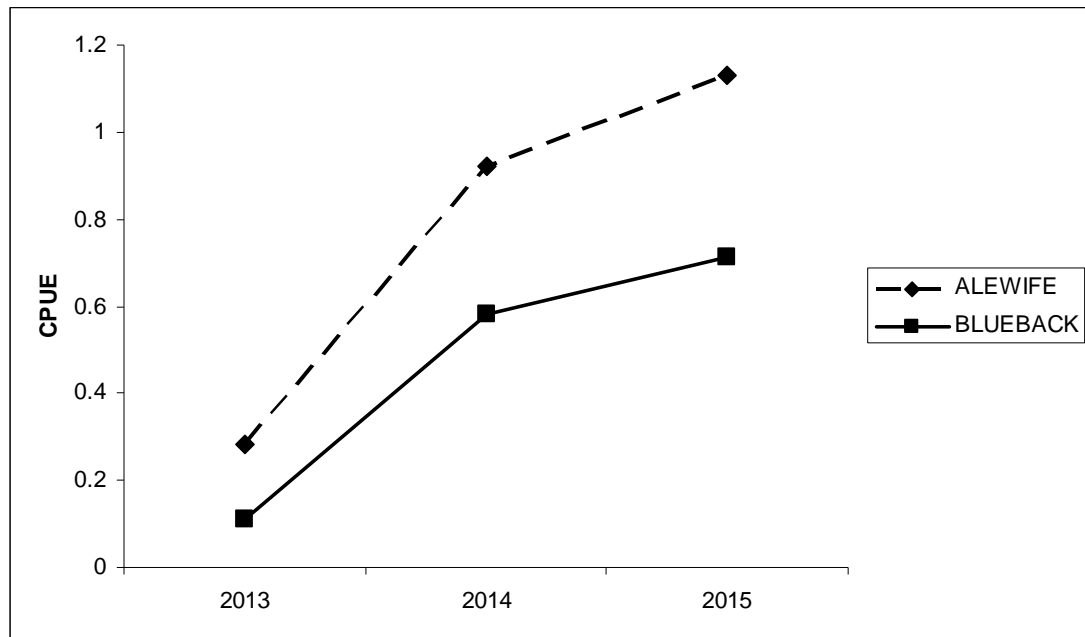


Figure 2. Catch of Alewife and Blueback per set of experimental sinking gill net set per hour fished in the North East River, 2013-2015. Only catch from the 2 ½" and 2 ¾" mesh panels were used.

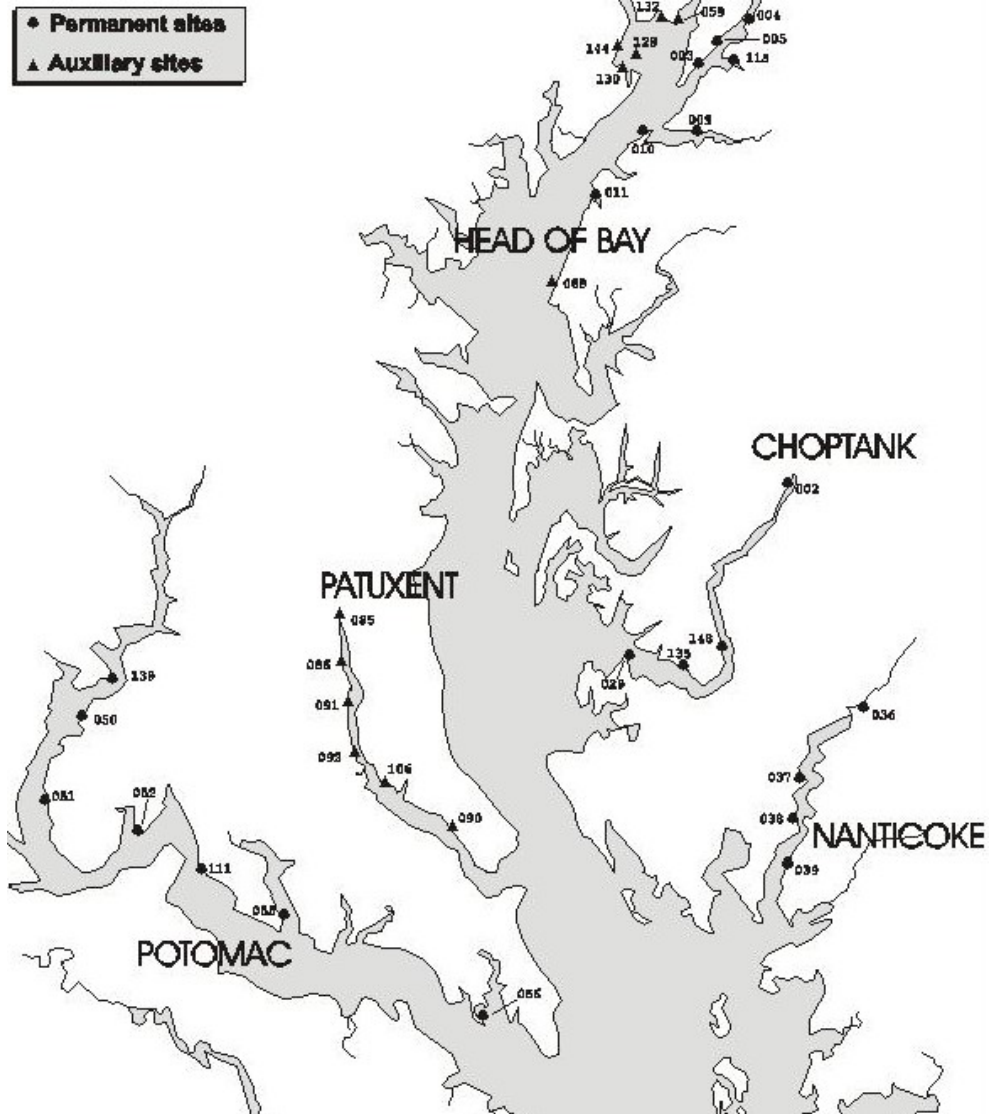


Figure 3. Maryland Chesapeake Bay juvenile striped bass survey site locations.



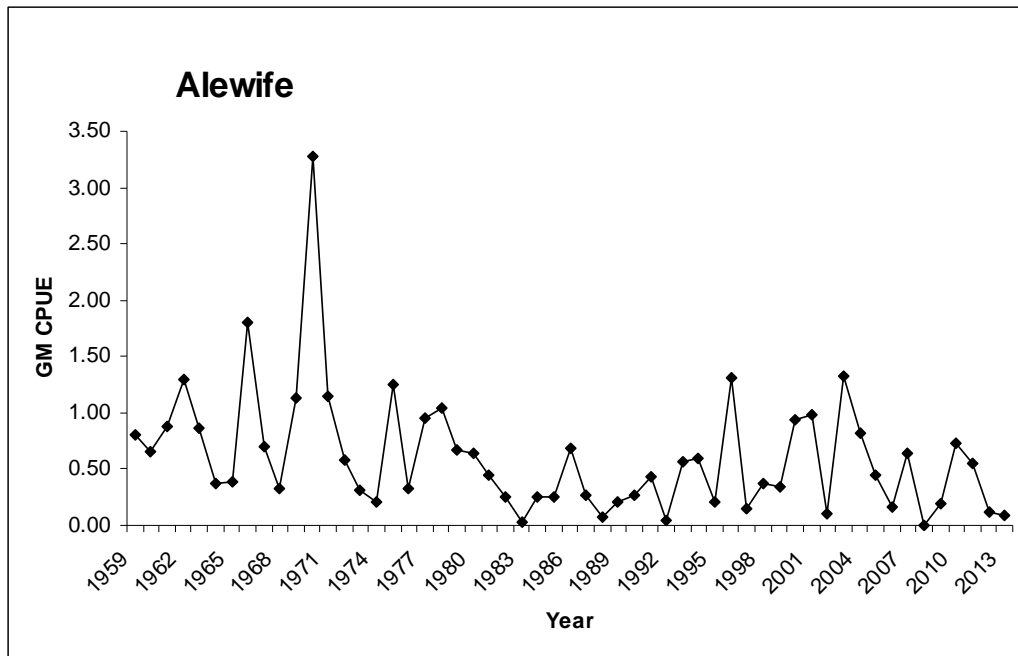


Figure 4. Bay-wide juvenile Alewife herring geometric mean CPUE (catch per haul), 1959-2014.

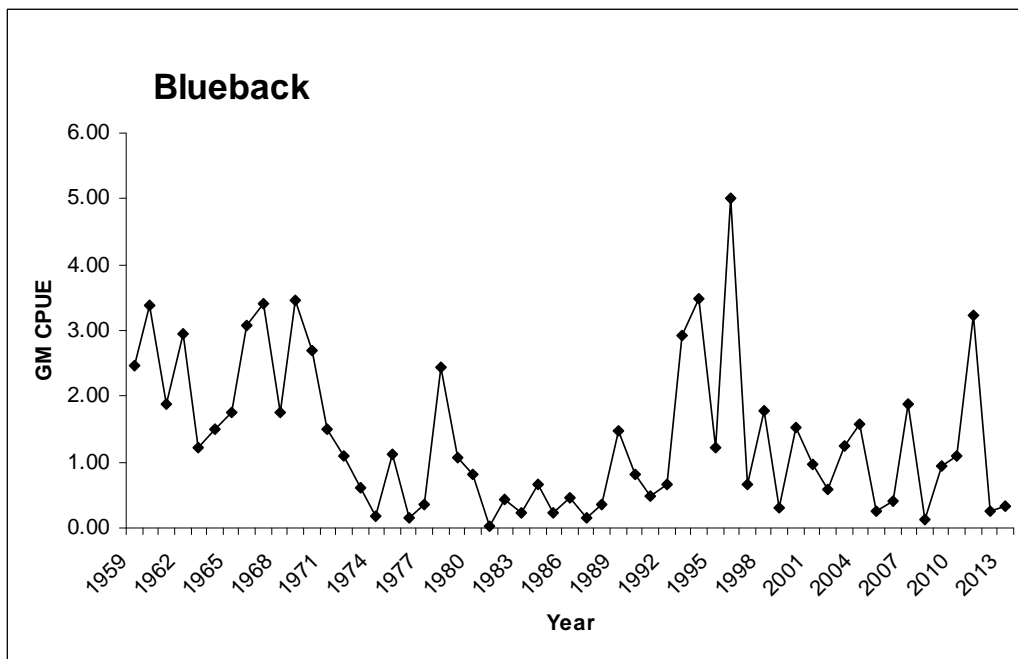


Figure 5. Bay-wide juvenile Blueback Herring geometric mean CPUE (catch per haul), 1959-2014.

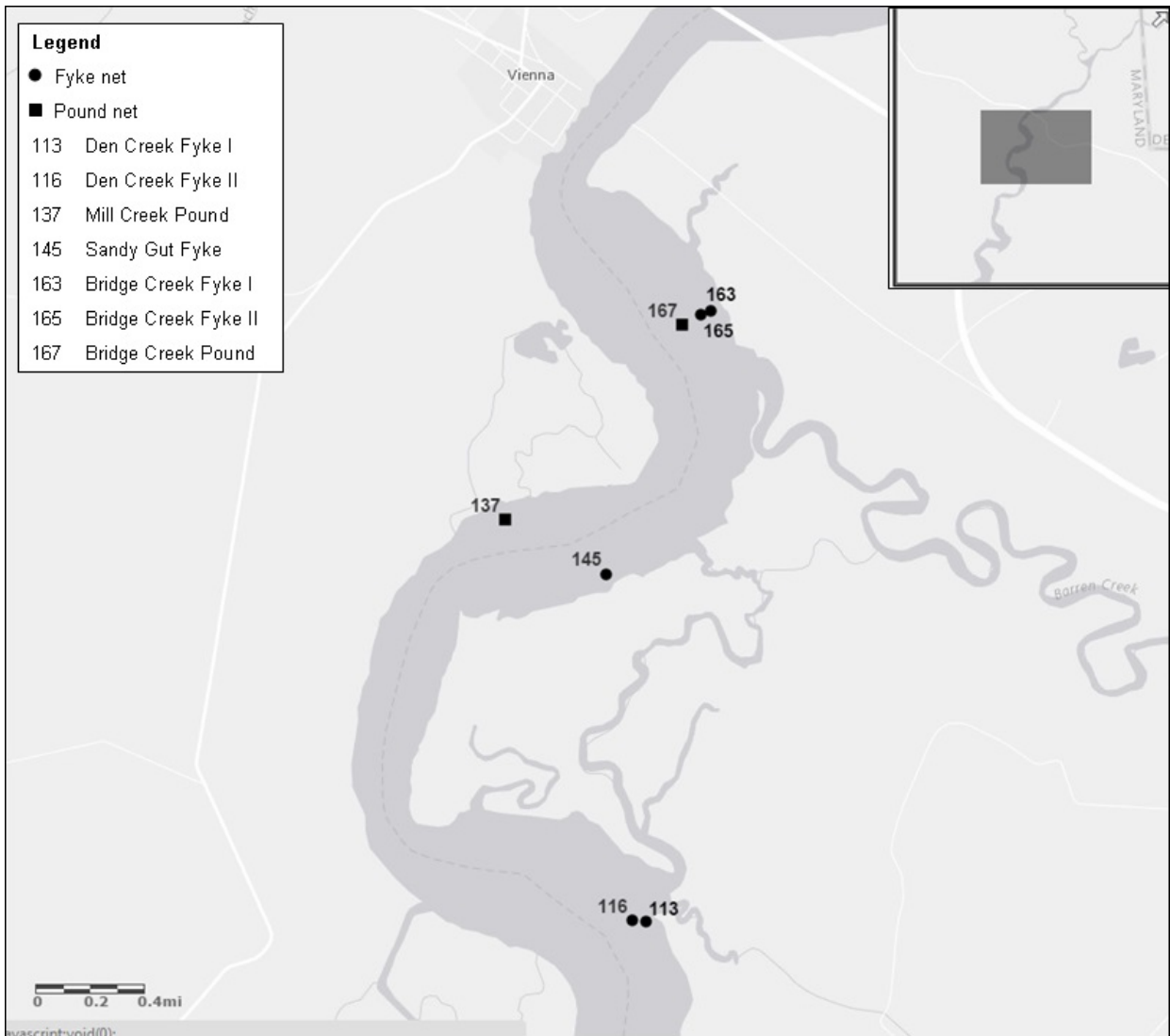


Figure 6. Nanticoke River pound and fyke net locations for 2014.

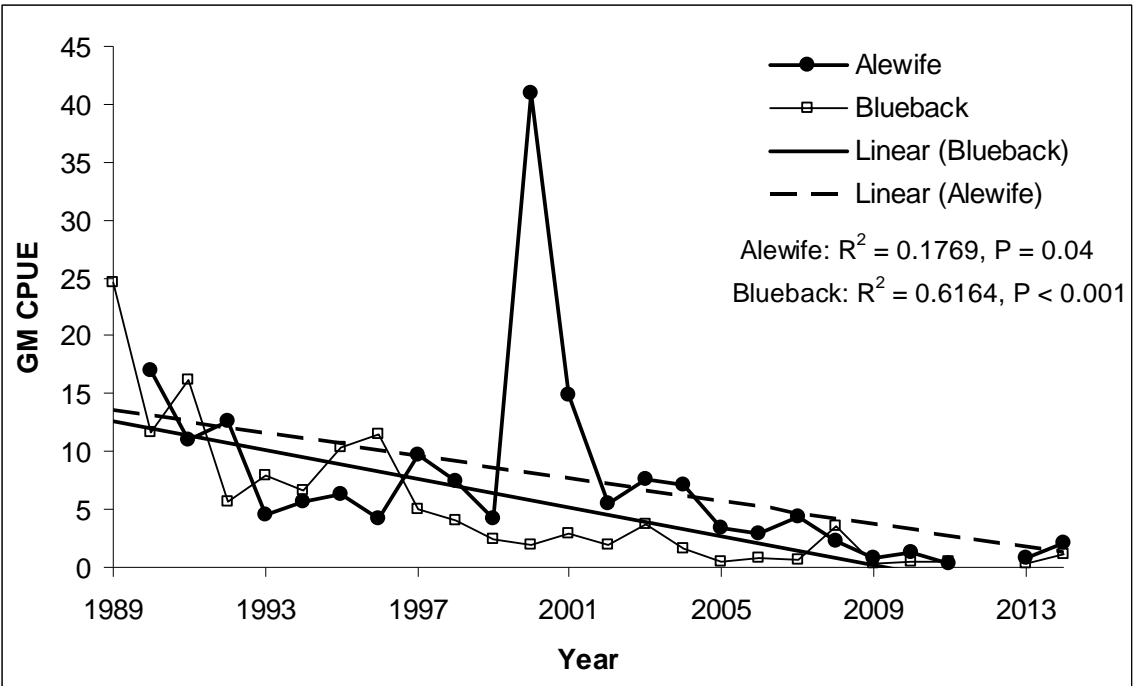


Figure 7. Geometric mean CPUE (catch per net day) of adult Alewife and Blueback Herring from Nanticoke River fyke nets, 1989-2014. No fyke nets were fished in 2012.

# **Appendix N. Virginia Department of Game and Inland Fisheries River Herring Monitoring Programs**

**(Alan Weaver)**

## **Tidal Appomattox River**

VDGIF conducts an Adult River Herring Spawning Run Survey in the tidal Appomattox River at Petersburg using boat electrofishing. Sampling was first conducted in 1995 and continues through the present with a few missing years (2006; 2008; 2013). The primary objectives of the survey are to establish a long-term time series of relative abundance indices (seasonal cumulative CPUE) and to monitor the biological structure of the spawning runs of Alewife and Blueback Herring in the upper tidal Appomattox River. Another major use of the herring data is for the evaluation of fish passage at Harvell Dam located at the head of tide. A Denil fishway was constructed in 1998. However, the dam, including the fishway, was removed in 2014.

### ***Survey Methods***

Sampling occurs on the upper tidal Appomattox River at several stations from the head of tide (just below Harvell Dam) down to the Interstate 95 area. High frequency boat electrofishing is conducted primarily with a john boat (4.3 m) outfitted with two anode droppers. The normal practice is to have one dipper on the bow deck collecting stunned fish. A sturdy nylon dip-net (12.7 mm mesh; 2.4 m fiberglass pole) with a trapezoidal shaped “head” are used for efficient capture. The general practice is to emit 4 to 5 amps at 500 to 1000 volts and 30 to 120 hz (most often 60 hz for adults). The result is a range of 2000 to 5000 watts. Sampling time per station ranges from 300 to 900 seconds and covers the same area in the same manner each time it is sampled. Sampling stations are pooled per date to generate a cumulative CPUE for the upper tidal reach of the Appomattox at Petersburg.

### ***Sampling Intensity***

Sampling occurs once a week beginning in late February and continues until river herring are no longer caught (typically late May or early June). In some years sampling occurs only fortnightly due to time constraints.

### ***Biological Sampling***

All river herring are counted and the sex of each fish is recorded. For females the spawning condition is noted (e.g. flowing; spent). Length and weight are taken on a subsample on each sampling date (usually 25 individuals per date). In some years, otoliths and scales are also collected for ageing purposes (fish are transported from the field to the lab on ice). We recently also started recording roe weight on sacrificed samples.

## ***Biases***

Environmental factors such as changing water temperature and day length are expected to affect CPUE over the course of the spawning run. River discharge and tidal conditions may increase or decrease effectiveness of the gear and thus may influence CPUE. Higher flow equates with increased turbidity that reduces fish visibility and increased flow can make boat maneuvering more challenging. River herring runs tend to occur in pulses so sampling only once per week over the course of the spawning season may result in missing spawning run strength peaks. American Shad, Hickory Shad and Striped Bass are also collected during river herring collections and while every effort is made to collect all target species some river herring may be missed during sampling. The skill of the dipper may affect CPUE.

## **Tidal Rappahannock River**

### ***Boat Electrofishing***

VDGIF conducts an Adult River Herring Spawning Run Survey in the tidal Rappahannock River at Fredericksburg using boat electrofishing. The primary objectives of the survey that began in 1995 are to establish a long-term time series of relative abundance indices (seasonal cumulative CPUE) and to monitor the biological structure of the spawning runs of Alewife and Blueback Herring in the upper tidal Rappahannock River. Another major objective was to collect pre Embrey Dam removal data to aid in the evaluation of the removal project that occurred in 2004/05.

### ***Survey Methods***

Sampling occurs on the upper tidal Rappahannock River at several stations from the Route 1 Bridge down to the City Docks area in Fredericksburg. High frequency boat electrofishing is conducted primarily with either a Smith-Root boat (4.9 m) with two anode droppers using two dippers or a smaller boat (4.3 m) with two droppers and one dipper. Dippers work from the bow deck to collect stunned fish. Sturdy nylon dip-nets (12.7 mm mesh; 2.4 m fiberglass pole) with a trapezoidal shaped “head” are used for efficient capture. The general practice is to emit 4 to 6 amps at 500 to 1000 volts and 30 to 120 hz (most often 60 hz for adults). The result is a range of 2000 to 6000 watts. Sampling time per station ranges from 500 to 900 seconds and covers the same area in the same manner each time it is sampled. Sampling stations are pooled per date to generate a cumulative CPUE for the upper tidal reach of the Rappahannock at Fredericksburg.

### ***Sampling Intensity***

Sampling occurs once a week beginning in late February and continues until river herring are no longer caught (typically late May or early June).

### ***Biological Sampling***

All river herring are counted and the sex of each fish is recorded. For females the spawning condition is noted (e.g. flowing; spent). Length and weight are taken on a subsample on each sampling date (usually 25 individuals per date). In some years, otoliths and scales are also collected for ageing purposes (fish

are transported from the field to the lab on ice). We recently also started recording roe weight on sacrificed samples.

### ***Biases***

Environmental factors such as changing water temperature and day length are expected to affect CPUE over the course of the spawning run. River discharge and tidal conditions may increase or decrease effectiveness of the gear and thus may influence CPUE. Higher flow equates with increased turbidity that reduces fish visibility and increased flow can make boat maneuvering more challenging. River herring runs tend to occur in pulses so sampling only once per week over the course of the spawning season may result in missing spawning run strength peaks. American Shad, Hickory Shad and Striped Bass are also collected during river herring collections and while every effort is made to collect all target species some river herring may be missed during sampling. Boat choice, number of dippers and skill of dippers may affect CPUE.

### ***Backpack electrofishing***

VDGIF began an Adult River Herring Spawning Run Survey in three tributaries of the upper tidal Rappahannock River near Fredericksburg in 2015 using a backpack electrofisher. Non-tidal reaches of Claiborne Run, White Oak Run and Hazel Run were sampled. The primary objectives of the pilot survey were to determine the presence or absence of a herring run in each tributary, to determine if herring are utilizing fish passage structures on some of the tributaries, to potentially establish a long-term time series of relative abundance indices (seasonal cumulative CPUE) and to monitor the biological structure of the spawning runs of Alewife and Blueback Herring in the tributaries. A pool and weir fishway was constructed on White Oak Run at Route 601 in 2005 and in early 2015 a nature-like fishway was completed on Claiborne Run at an abandoned road crossing approximately one mile upstream of Claiborne's confluence with the tidal Rappahannock.

### ***Survey Methods***

Sampling occurred with a Halltech backpack electrofisher primarily with two netters in each tributary at fixed locations. Fish were held in the stream in live pens or large tubs along the shoreline. Temperature and discharge was measured at each site. In Claiborne Run three sections were sampled: 1) the 100 m downstream of the nature-like fishway, 2) the seven pools of the nature-like fishway downstream of the road, and 3) the 100 m upstream of the road crossing. Several 100 m sections of Hazel Run were sampled near passable road crossings. In White Oak Run two sections were sampled: 1) the 100 m downstream of the pool and weir fishway at the road crossing, and 2) the 100 m upstream of the road crossing/fishway. CPUE was calculated for each sampling event.

### ***Sampling Intensity***

Sampling occurred once a week beginning in mid-March and continued into May until river herring were no longer caught or conditions became unfavorable for herring runs (increased temperature; low flow).

### ***Biological Sampling***

All river herring were counted and the sex of each fish was recorded. For females the spawning condition was noted (e.g. flowing; spent). Length and weight were taken on a subsample on each sampling date (usually 25 individuals per date if available). Some fish were sacrificed to take otoliths and scales for ageing purposes (fish transported on ice to the lab). We recently also started recording roe weight on sacrificed samples.

### ***Biases***

Environmental factors such as changing water temperature and day length are expected to affect CPUE over the course of the spawning run. Stream discharge may increase or decrease effectiveness of the gear and thus may influence CPUE. In wadeable streams high discharge can preclude the ability to sample but herring may still be running during such events. Higher flow also equates with increased turbidity that reduces fish visibility. River herring runs tend to occur in pulses so sampling only once per week over the course of the spawning season may result in missing spawning run strength peaks or missing the presence of a herring run altogether. The skill of dippers may affect CPUE.

### **Non-tidal Rappahannock River**

VDGIF conducts an Adult River Herring Spawning Run Survey in the non-tidal Rappahannock River within and upstream of the Fall Zone at Fredericksburg using boat electrofishing. Objectives of the survey are to establish a long-term time series of relative abundance indices (seasonal cumulative CPUE) and to monitor the biological structure of the spawning runs of Alewife and Blueback Herring in the non-tidal Rappahannock River. Another major objective is to collect post Embrey Dam removal data to aid in the evaluation of the removal project that occurred in 2004/05.

### ***Survey Methods***

Sampling occurs on the non-tidal Rappahannock River at several stations within and upstream of the Fall Zone at Fredericksburg. The area immediately downstream of Embrey Dam was sampled beginning in 1995 until the dam was removed in 2004/05. Sampling at Motts Run (5 miles upstream of dam removal) was initiated in 2004 and sampling at Kellys Ford (28 miles upstream) was initiated in 2008. High frequency boat electrofishing is conducted with a small john boat (4.3 m) with two droppers and one dipper. The dipper works from the bow deck to collect stunned fish. A sturdy nylon dip-nets (12.7 mm mesh; 2.4 m fiberglass pole) with a trapezoidal shaped "head" is used for efficient capture. The general practice is to emit 4 to 5 amps at 500 to 1000 volts and 30 to 120 hz (most often 60 hz for adults). The result is a range of 2000 to 5000 watts. Sampling time per station ranges from 500 to 900 seconds and covers the same area in the same manner each time it is sampled. Sampling stations are pooled per date per sampling reach to generate a cumulative CPUE for each non-tidal reach of the Rappahannock.

### ***Sampling Intensity***

Sampling occurs generally fortnightly (sometimes weekly) beginning in late March and continues until river herring are no longer caught (typically late May or early June).

### ***Biological Sampling***

All river herring are counted and the sex of each fish is recorded. For females the spawning condition is noted (e.g. flowing; spent). Currently, length and weight are taken on each specimen since river herring are not yet abundant at these sites. In some years, otoliths and scales are also collected for ageing purposes (fish are transported from the field to the lab on ice). We recently also started recording roe weight on sacrificed samples.

### ***Biases***

Environmental factors such as changing water temperature and day length are expected to affect CPUE over the course of the spawning run. River discharge and tidal conditions may increase or decrease effectiveness of the gear and thus may influence CPUE. Higher flow equates with increased turbidity that reduces fish visibility and increased flow can make boat maneuvering more challenging. River herring runs tend to occur in pulses so sampling only once per week over the course of the spawning season may result in missing spawning run strength peaks. American Shad, Hickory Shad and Striped Bass are also collected during river herring collections and while every effort is made to collect all target species some river herring may be missed during sampling. The skill of dippers may affect CPUE.

### **Tidal Chickahominy River**

VDGIF conducts an Adult River Herring Spawning Run Survey in the tidal Chickahominy River immediately downstream of Walkers Dam using boat electrofishing. For several years in the 1990s river herring were collected below Walkers Dam to be transported to the middle James River in an attempt to increase the James spawning run. That data is not part of the long-term time series because it was a very biased collection method for the transport operation. The primary objectives of the current survey are to establish a long-term time series of relative abundance indices (seasonal cumulative CPUE) and to monitor the biological structure of the spawning runs of Alewife and Blueback Herring in the tidal Chickahominy River below Walkers Dam. The time series is: 1999-2001, 2007-2008, and 2011-2015. Another major objective is the evaluation of fish passage through the Denil fishway on Walkers Dam.

### ***Survey Methods***

Sampling occurs on the upper tidal Chickahominy River at three stations downstream of Walkers Dam in Lanexa. High frequency boat electrofishing is conducted primarily with a Smith-Root boat outfitted with two anode droppers. The normal practice is to have one dipper on the bow deck collecting stunned fish (the impoundment and river upstream of the dam is usually sampled on the same day requiring the faster Smith Root boat). Occasionally, a smaller boat with two anode droppers and one dipper is used if the Smith-Root boat is temporarily out of service. A sturdy nylon dip-net (12.7 mm mesh; 2.4 m



fiberglass pole) with a trapezoidal shaped “head” is used for efficient capture. The general practice is to emit 4 to 6 amps at 500 to 1000 volts and 30 to 120 hz (most often 60 hz for adults). The result is a range of 2000 to 6000 watts. Sampling time per station is 500 seconds and covers the same area in the same manner each time it is sampled. Sampling stations are pooled per date to generate a cumulative CPUE for this upper tidal reach of the Chickahominy below Walkers Dam.

### ***Sampling Intensity***

Sampling occurs either weekly or fortnightly beginning in late February and continues until river herring are no longer caught (typically late May).

### ***Biological Sampling***

All river herring are counted and the sex of each fish is recorded. For females the spawning condition is noted (e.g. flowing; spent). Length and weight are taken on a subsample on each sampling date (usually 25 individuals per date). In some years, otoliths and scales are also collected for ageing purposes (fish are transported from the field to the lab on ice). We recently also started recording roe weight on sacrificed samples.

### ***Biases***

Environmental factors such as changing water temperature and day length are expected to affect CPUE over the course of the spawning run. River discharge and tidal conditions may increase or decrease effectiveness of the gear and thus may influence CPUE. Higher flow equates with increased turbidity that reduces fish visibility and increased flow can make boat maneuvering more challenging. River herring runs tend to occur in pulses so sampling only once per week over the course of the spawning season may result in missing spawning run strength peaks. American Shad, Hickory Shad and Striped Bass are also collected during river herring collections and while every effort is made to collect all target species some river herring may be missed during sampling. Boat choice, number of dippers and skill of dippers may affect CPUE.

### **Non-tidal Chickahominy River**

VDGIF conducts an Adult River Herring Spawning Run Survey in the non-tidal Chickahominy River upstream of Walkers Dam using boat electrofishing within Chickahominy Lake and the river just upstream of the lake. Two objectives of the survey are to establish a long-term time series of relative abundance indices (seasonal cumulative CPUE) and to monitor the biological structure of the spawning runs of Alewife and Blueback Herring in the non-tidal Chickahominy River upstream of Walkers Dam. The time series is: 2011-2015. Another major objective is the evaluation of fish passage through the Denil fishway on Walkers Dam.

### ***Survey Methods***

Sampling occurs on Chickahominy Lake upstream of Walkers Dam and in the Chickahominy River just upstream of the lake. High frequency boat electrofishing is conducted primarily with a Smith-Root boat outfitted with two anode droppers. The normal practice is to have one dipper on the bow deck collecting stunned fish (the faster Smith Root boat is needed to get to the upstream sites; downstream of the dam is usually sampled on the same day). Occasionally, a smaller boat with two anode droppers and one dipper is used if the Smith-Root boat is temporarily out of service. A sturdy nylon dip-net (12.7 mm mesh; 2.4 m fiberglass pole) with a trapezoidal shaped “head” is used for efficient capture. The general practice is to emit 4 to 6 amps at 500 to 1000 volts and 30 to 120 hz (most often 60 hz for adults). The result is a range of 2000 to 6000 watts. Sampling time per station is 500 to 900 seconds and covers the same area in the same manner each time it is sampled. Sampling stations are pooled per date to generate a cumulative CPUE for this non-tidal reach of the Chickahominy upstream of Walkers Dam.

### ***Sampling Intensity***

Sampling occurs either weekly or fortnightly beginning in March and continues until river herring are no longer caught (typically late May).

### ***Biological Sampling***

All river herring are counted and the sex of each fish is recorded. For females the spawning condition is noted (e.g. flowing; spent). Length and weight are taken on a subsample on each sampling date (usually 25 individuals per date). In some years, otoliths and scales are also collected for ageing purposes (fish are transported from the field to the lab on ice). We recently also started recording roe weight on sacrificed samples.

### ***Biases***

Environmental factors such as changing water temperature and day length are expected to affect CPUE over the course of the spawning run. River discharge and tidal conditions may increase or decrease effectiveness of the gear and thus may influence CPUE. Higher flow equates with increased turbidity that reduces fish visibility and increased flow can make boat maneuvering more challenging. River herring runs tend to occur in pulses so sampling only once per week over the course of the spawning season may result in missing spawning run strength peaks. American Shad, Hickory Shad and Striped Bass are also collected during river herring collections and while every effort is made to collect all target species some river herring may be missed during sampling. Boat choice, number of dippers and skill of dippers may affect CPUE.

### **Tidal James River**

VDGIF conducts an Adult River Herring Spawning Run Survey in the tidal James River at Richmond using boat electrofishing. Sampling was first conducted in 1995 and then from 2002-2015 (Virginia Commonwealth University conducted sampling in several years between 1996 and 2001 in the tidal

James under contract by the City of Richmond). The primary objectives of the survey are to establish a long-term time series of relative abundance indices (seasonal cumulative CPUE) and to monitor the biological structure of the spawning runs of Alewife and Blueback Herring in the upper tidal James River. Several dams in the Fall Zone of the James have either been notched or fitted with a fishway. Upper tidal herring data also contributes to the evaluation of fish passage through the Fall Zone although it is primarily American Shad that ascend through the Fall Zone and into the middle James through Boshers Dam fishway.

### ***Survey Methods***

Sampling occurs on the upper tidal James River at several stations in the 14<sup>th</sup> Street and Interstate 95 bridges area. High frequency boat electrofishing is conducted primarily with a Smith-Root boat outfitted with two anode droppers. The normal practice is to have two dippers on the bow deck collecting stunned fish. Occasionally, a smaller boat with one dipper is used if the Smith-Root boat is temporarily out of service. Sturdy nylon dip-nets (12.7 mm mesh; 2.4 m fiberglass pole) with a trapezoidal shaped “head” are used for efficient capture. The general practice is to emit 4 to 6 amps at 500 to 1000 volts and 30 to 120 hz (most often 60 hz for adults). The result is a range of 2000 to 6000 watts. Sampling time per station ranges from 300 to 500 seconds and covers the same area in the same manner each time it is sampled. Five to seven such sampling stations are pooled per date to generate a cumulative CPUE for the upper tidal reach of the James at Richmond.

### ***Sampling Intensity***

Sampling occurs once a week beginning in late February and continues until river herring are no longer caught (typically late May or early June).

### ***Biological Sampling***

All river herring are counted and the sex of each fish is recorded. For females the spawning condition is noted (e.g. flowing; spent). Length and weight are taken on a subsample on each sampling date (usually 25 individuals per date). In some years, otoliths and scales are also collected for ageing purposes (fish are transported from the field to the lab on ice). We recently also started recording roe weight on sacrificed samples. In some years, fin clips are taken for various genetic studies to be done by others.

### ***Biases***

Environmental factors such as changing water temperature and day length are expected to affect CPUE over the course of the spawning run. River discharge and tidal conditions may increase or decrease effectiveness of the gear and thus may influence CPUE. Higher flow equates with increased turbidity that reduces fish visibility and increased flow can make boat maneuvering more challenging. River herring runs tend to occur in pulses so sampling only once per week over the course of the spawning season may result in missing spawning run strength peaks. American Shad, Hickory Shad and Striped Bass are also collected during river herring collections and while every effort is made to collect all target species some river herring may be missed during sampling. Boat choice, number of dippers and skill of dippers may affect CPUE.

## **Non-tidal James River (Richmond Fall Zone)**

VDGIF conducts an Adult River Herring Spawning Run Survey in the Non-tidal James River at Richmond using boat electrofishing. Sampling stations are located in the Browns Island Dam pool (breach), downstream of Williams Island Z Dam (notch) and downstream of Boshers Dam (vertical slot fishway). The primary objectives of the survey are to establish a long-term time series of relative abundance indices (seasonal cumulative CPUE) and to monitor the biological structure of the spawning runs of Alewife and Blueback Herring in the Non-tidal James River at Richmond. The time series is: 1995-1996 and 1999-2015. Another objective is the evaluation of fish passage through the several dams located in the Fall Zone of the James at Richmond although river herring are rarely seen in these sample sites (American Shad are common in these samples).

### ***Survey Methods***

Sampling occurs on the James River within the Fall Zone at Richmond. High frequency boat electrofishing is conducted with either a Smith-Root boat (4.9 m) outfitted with two anode droppers using two dippers (Boshers) or a smaller john boat (4.3 m) using one dipper (Browns pool; Williams). Sturdy nylon dip-nets (12.7 mm mesh; 2.4 m fiberglass pole) with a trapezoidal shaped “head” are used for efficient capture. The general practice is to emit 4 to 6 amps at 500 to 1000 volts and 30 to 120 hz (most often 60 hz for adults). The result is a range of 2000 to 6000 watts. Sampling time per station ranges from 500 to 900 seconds and covers the same area in the same manner each time it is sampled. Sampling stations are pooled per date per river reach to generate a cumulative CPUE for each reach (Browns, Williams, Boshers) of the non-tidal James River (Fall Zone at Richmond).

### ***Sampling Intensity***

Sampling occurs primarily weekly or fortnightly beginning in March and continues until river herring are no longer caught (typically May). Boshers tends to be a weekly sample while the Browns Pool, for example is more likely to be sampled every other week.

### ***Biological Sampling***

All river herring are counted and the sex of each fish is recorded. For females the spawning condition is noted (e.g. flowing; spent). Length and weight are taken on all specimens on each sampling date because herring are rare at these sites. In some years, otoliths and scales are also collected for ageing purposes (fish are transported from the field to the lab on ice). We recently also started recording roe weight on sacrificed samples.

### ***Biases***

Environmental factors such as changing water temperature and day length are expected to affect CPUE over the course of the spawning run. River discharge and tidal conditions may increase or decrease effectiveness of the gear and thus may influence CPUE. Higher flow equates with increased turbidity that reduces fish visibility and increased flow can make boat maneuvering more challenging. River

herring runs tend to occur in pulses so sampling only once per week over the course of the spawning season may result in missing spawning run strength peaks. American Shad, Hickory Shad and Striped Bass are also collected during river herring collections and while every effort is made to collect all target species some river herring may be missed during sampling. Boat choice, number of dippers and skill of dippers may affect CPUE.

### **Tidal Mattaponi River**

VDGIF conducted an Adult River Herring Spawning Run Survey in the tidal Mattaponi River in the Aylett area using boat electrofishing. Sampling was first conducted in 2000 and continued through 2012 (no sampling in 2003). The primary objectives of the survey were to establish a long-term time series of relative abundance indices (seasonal cumulative CPUE) and to monitor the biological structure of the spawning runs of Alewife and Blueback Herring in the tidal Mattaponi River. Another objective was to collect target species data in the mainstem Mattaponi due to several potential tributary fish passage projects (e.g. dam failure resulting in permanent passage on a Herring Creek dam in 2007). Sampling may resume on this river as time allows in the future to update the time series.

### ***Survey Methods***

Sampling occurred on the tidal Mattaponi River at several stations near Aylett. High frequency boat electrofishing was conducted primarily with a john boat (4.3 m) outfitted with two anode droppers. The normal practice was to have one dipper on the bow deck collecting stunned fish. A sturdy nylon dip-net (12.7 mm mesh; 2.4 m fiberglass pole) with a trapezoidal shaped “head” was used for efficient capture. The general practice was to emit 4 to 5 amps at 500 to 1000 volts and 30 to 120 hz (most often 60 hz for adults). The result was a range of 2000 to 5000 watts. Sampling time per station was 900 seconds and covered the same area in the same manner each time it was sampled. Up to four such sampling stations were pooled per date to generate a cumulative CPUE for the tidal Mattaponi near Aylett.

### ***Sampling Intensity***

Sampling occurred roughly fortnightly beginning in March and continuing until river herring were no longer caught (typically late May or early June).

### ***Biological Sampling***

All river herring were counted and the sex of each fish recorded. For females the spawning condition was noted (e.g. flowing; spent). Length and weight were taken on a subsample on each sampling date (usually 25 individuals per date).

### ***Biases***

Environmental factors such as changing water temperature and day length were expected to affect CPUE over the course of the spawning run. River discharge and tidal conditions may have increased or decreased effectiveness of the gear and thus may have influenced CPUE. Higher flow equates with

increased turbidity that reduces fish visibility and increased flow can make boat maneuvering more challenging. River herring runs tend to occur in pulses so sampling only once per week over the course of the spawning season may result in missing spawning run strength peaks. American Shad, Hickory Shad and Striped Bass were also collected during river herring collections and while every effort was made to collect all target species some river herring might have been missed during sampling. The skill of the dipper may have affected CPUE.

### **Non-tidal South Anna River**

VDGIF conducted an Adult River Herring Spawning Run Survey in the South Anna River downstream of Route 1 from 1994 to 2009 using boat electrofishing. Sampling was not conducted in the following years: 1995, 1997, 2006, and 2008. The primary objectives of the survey were to establish a long-term time series of relative abundance indices (seasonal cumulative CPUE) and to monitor the biological structure of the spawning runs of Alewife and Blueback Herring in the South Anna River downstream of Ashland Mill Dam. Another major objective was to collect pre fish passage data in the South Anna River ahead of fish passage being provided at Ashland Mills Dam (either fishway or removal; no fish passage as of 2015). Sampling may resume on this river as time allows in the future to update the time series and if there is progress toward fish passage.

#### ***Survey Methods***

Sampling occurred on the tidal South Anna River at several stations downstream of Ashland Mill Dam. High frequency boat electrofishing was conducted primarily with a john boat (4.3 m) outfitted with two anode droppers. The normal practice was to have one dipper on the bow deck collecting stunned fish. A sturdy nylon dip-net (12.7 mm mesh; 2.4 m fiberglass pole) with a trapezoidal shaped “head” was used for efficient capture. The general practice was to emit 4 to 5 amps at 500 to 1000 volts and 30 to 120 hz (most often 60 hz for adults). The result was a range of 2000 to 5000 watts. Sampling time per station was 500-900 seconds and covered the same area in the same manner each time it was sampled. Up to four such sampling stations were pooled per date to generate a cumulative CPUE for the South Anna below Ashland Mill Dam.

#### ***Sampling Intensity***

Sampling occurred roughly fortnightly beginning in March and continuing until river herring were no longer caught (typically late May or early June).

#### ***Biological Sampling***

All river herring were counted and the sex of each fish recorded. For females the spawning condition was noted (e.g. flowing; spent). Length and weight were taken on a subsample on each sampling date (up to 25 individuals per date).

## ***Biases***

Environmental factors such as changing water temperature and day length were expected to affect CPUE over the course of the spawning run. River discharge and tidal conditions may have increased or decreased effectiveness of the gear and thus may have influenced CPUE. Higher flow equates with increased turbidity that reduces fish visibility and increased flow can make boat maneuvering more challenging. River herring runs tend to occur in pulses so sampling only once per week over the course of the spawning season may result in missing spawning run strength peaks. American Shad, Hickory Shad and Striped Bass were also collected during river herring collections and while every effort was made to collect all target species some river herring might have been missed during sampling. The skill of the dipper may have affected CPUE.

## **Juvenile River Herring Survey Tidal Rappahannock River**

VDGIF conducts a juvenile alosine survey in the tidal Rappahannock River between Port Royal (river mile 79) and Fredericksburg (river mile 108). The primary objectives are to collect American Shad juveniles to check for hatchery marks (otc) on the otoliths and to obtain an inter-annual trend of abundance for American Shad, Alewife and Blueback Herring. American Shad fry stocking ceased in 2014. Collections beginning in 2015 will only be for abundance measures and biological data.

## ***Survey Methods***

Bow mounted push net sampling is conducted at night when the fish exhibit negative-phototropic behavior that orients them closer to the surface and thus makes them more vulnerable to the gear. A 5.2 m jon boat with a 50hp motor that is operated from a right side console is outfitted with the push net gear. We now use a circular push net with a diameter of 0.76 m with a 0.45 m<sup>2</sup> collection area). We use a 3.18 mm mesh nylon net early in the season and switch to a 6.4 mm mesh size about mid-summer. Six push net sites are randomly selected from a larger number of sites per river reach (approximately 10 mile reaches). Pushes range from 5 to 10 minutes in length and the boat is operated to maintain a range of 2500 to 3000 RPM. A flow meter is mounted to the push net frame to determine the volume of water sampled during a push. Juvenile fish density (CPUE) is expressed as the number of fish per 100 cubic meters of water sampled.

Boat electrofishing is conducted for juvenile alosines because as the fish grow their ability to avoid the push net gear increases. Boat electrofishing also allows for sampling of shallower, shoreline habitat that is not accessible with the push net boat. Six to eight sites that represent a variety of habitats (e.g., shoreline with woody debris, vegetated shoreline, mid-channel, etc.) are chosen randomly for each sample event within river sections (approximately 10 miles). Each electrofishing sample is 10 minutes in length. The same techniques and equipment are used as described for adult monitoring with the exception that 120 hz is the normal setting because higher frequencies are more effective on relatively smaller fish. Dip nets with a 6.4 mm mesh size are used.

### ***Sampling Intensity***

Push net sampling occurs once a week from the first week in June through July and sometimes into August. Boat electrofishing occurs weekly from August through October and sometimes into November. Six to eight random stations per night are sampled.

### ***Biological Sampling***

River herring are separated by station and placed on ice and brought back to VDGIF for biologic sampling. Alewife and Blueback Herring caught at each station are identified and counted. Individual length and weight is taken on 25 fish per species per day. Max/min and pooled weight is taken on the remaining fish.

### ***Biases***

Environmental factors such as changing water temperature and day length may affect CPUE for both gears depending on whether juveniles are outmigrating or in a holding pattern. Juvenile American Shad are also collected during juvenile river herring collections. This does not bias push net samples but may bias electrofishing samples due to site selectivity by dippers. The skill of dippers may affect electrofishing CPUE. Catchability may be affected by light conditions mainly for the push net sampling (i.e. darker nights may yield increased CPUEs).

### **Juvenile River Herring Survey Tidal James River**

VDGIF conducts a juvenile alosine survey in the tidal James River between river miles 80 and 104 (City of Richmond). The primary objectives are to collect American Shad juveniles to check for hatchery marks (otc) on the otoliths and to obtain an inter-annual trend of abundance for American Shad, Alewife and Blueback Herring.

### ***Survey Methods***

Bow mounted push net sampling is conducted at night when the fish exhibit negative-phototropic behavior that orients them closer to the surface and thus makes them more vulnerable to the gear. A 5.2 m jon boat with a 50hp motor that is operated from a right side console is outfitted with the push net gear. We now use a circular push net with a diameter of 0.76 m with a 0.45 m<sup>2</sup> collection area). We use a 3.18 mm mesh nylon net early in the season and switch to a 6.4 mm mesh size about mid-summer. Six push net sites are randomly selected from a larger number of sites per river reach (approximately 10 mile reaches). Pushes range from 5 to 10 minutes in length and the boat is operated to maintain a range of 2500 to 3000 RPM. A flow meter is mounted to the push net frame to determine the volume of water sampled during a push. Juvenile fish density (CPUE) is expressed as the number of fish per 100 cubic meters of water sampled.

Boat electrofishing is conducted for juvenile alosines because as the fish grow their ability to avoid the push net gear increases. Boat electrofishing also allows for sampling of shallower, shoreline habitat that



is not accessible with the push net boat. Six to eight sites that represent a variety of habitats (e.g., shoreline with woody debris, vegetated shoreline, mid-channel, etc.) are chosen randomly for each sample event within river sections (approximately 10 miles). Each electrofishing sample is 10 minutes in length. The same techniques and equipment are used as described for adult monitoring with the exception that 120 hz is the normal setting because higher frequencies are more effective on relatively smaller fish. Dip nets with a 6.4 mm mesh size are used.

### ***Sampling Intensity***

Push net sampling occurs once a week from the first week in June through July and sometimes into August. Boat electrofishing occurs weekly from August through October and sometimes into November. Six to eight random stations per night are sampled.

### ***Biological Sampling***

River herring are separated by station and placed on ice and brought back to VDGIF for biologic sampling. Alewife and Blueback Herring caught at each station are identified and counted. Individual length and weight is taken on 25 fish per species per day. Max/min and pooled weight is taken on the remaining fish.

### ***Biases***

Environmental factors such as changing water temperature and day length may affect CPUE for both gears depending on whether juveniles are outmigrating or in a holding pattern. Juvenile American Shad are also collected during juvenile river herring collections. This does not bias push net samples but may bias electrofishing samples due to site selectivity by dippers. The skill of dippers may affect electrofishing CPUE. Catchability may be affected by light conditions mainly for the push net sampling (i.e. darker nights may yield increased CPUEs).

## **Appendix O. Virginia Institute of Marine Science River Herring Monitoring Programs**

**(Dr. Eric Hilton and Dr. Pat McGrath)**

### **River Herring Spawning Stock Survey – Drift Gillnet**

VIMS has conducted a River Herring Spawning Stock Survey using a drift gillnet since 2014. The primary objectives of this survey are to establish a time series of relative abundance indices (aggregate CPUE) and to monitor the biological structure of the spawning runs of Alewife and Blueback Herring.

#### ***Survey Methods***

Sampling occurs on the Chickahominy River approximately 700 yards below Walkers Dam. One drift gillnet (300' x 8'), consisting of alternating 50' panels of 2.5" and 3.0" stretched mesh, is set for one hour during morning slack tide

#### ***Sampling Intensity***

Sampling occurs once a week beginning in February and continues until river herring are no longer caught (typically early May).

#### ***Biological Sampling***

All river herring are separated by species and mesh, placed on ice, and brought back to VIMS for biologic sampling. Aggregate counts and weights of male and female specimens of both species are taken for each mesh size. In addition, 20 females per species (Alewife and Blueback Herring), per mesh are individually measured, weighed, and have scales and otoliths removed. Beginning in 2016, 10 males per species, per mesh will also be sampled using the same protocol.

#### ***Biases***

This study only concentrates on the Chickahominy River population. The net is set near the spawning grounds and may encounter fish moving up and down the river. River flow and tidal conditions may increase or decrease effectiveness of the gear during the relatively small sampling period.

### **River Herring Spawning Stock Survey – Anchor Gillnet**

In 2015, VIMS began an annual survey to study Alewife and Blueback Herring spawning stocks. The primary objectives are to establish an index of relative abundance (area under the CPUE curve) and to monitor the biological structure of the spawning run. This survey was established in an effort to avoid gear and location biases encountered in the drift gillnet survey. Blueback Herring CPUE is calculated using only 2.5" mesh nets. Alewife CPUE includes catches from both 2.5" and 3.0" mesh nets.

### ***Survey Methods***

Sampling occurs at the Chickahominy River mouth. Two (300' x 6'; 2.5" stretched mesh) gillnets and two (300' x 8'; 3.0" stretched mesh) anchor gillnets are set parallel to the current. All nets are constructed with top float lines and lead bottom lines. Additional larger floats are added every 50' to ensure that fishing occurs from the surface down.

### ***Sampling Intensity***

Sampling begins in February and continues until river herring are no longer caught (typically early May). Nets are set for 24 hours on two consecutive days each week.

### ***Biological Sampling***

All river herring are separated by species and mesh, placed on ice, and brought back to VIMS for biologic sampling. Aggregate counts and weights of male and female specimens of both species are taken for each mesh size. In addition, 20 females per species (Alewife and Blueback Herring), per net are individually measured, weighed, and have scales and otoliths removed. Beginning in 2016, 10 males per species, per mesh will also be sampled using the same protocol.

### ***Biases***

This study only concentrates on the Chickahominy River population. There is a possibility of encountering James River proper river herring milling at the mouth of the Chickahominy River before continuing on with their run up the main river.

### **Juvenile River Herring Abundance Survey**

In 2014, VIMS began an annual survey to study juvenile Alewife and Blueback Herring abundance. The primary objectives are to establish a relative juvenile abundance index (geometric mean of CPUE) and to relate recruitment indices to relative year-class strength and age-structure of spawning adults.

### ***Survey Methods***

Sampling occurs from the Chickahominy River mouth to 20 miles upstream using a mamou trawl. The mamou trawl is a 6.7 m x 1.8 m floating surface trawl constructed of 35 mm high density polyethylene netting. The cod end is constructed of 36 mm netting with a 20 mm removable liner. The net consists of 15.2 m bridles connected to 36 x 18 floating mullet doors and 30.5 m tow lines. The survey follows a stratified random sampling design. The river is divided into four 5 mile blocks and each block is divided into five 1 mile stations. Three stations per 5 mile block are randomly selected for a total of 12 stations. Five minute tows travelling with the current are performed at each station. Sampling begins thirty minutes after sunset.

### ***Sampling Intensity***

Sampling occurs once a week from the first week in June to the last week in September. Twelve random stations per night are sampled.

### ***Biological Sampling***

River herring are separated by station and placed on ice and brought back to VIMS for biologic sampling. Alewife and Blueback Herring caught at each station are identified and counted. Ten individuals of each species from each station are measured and weighed. Starting in 2016, aggregate weights of each species per station will be taken.

### ***Biases***

This study only concentrates on the Chickahominy River population. Alewives are not well represented in the catch. 2014 data suggests that gear escapement occurs when individuals reach 65mm FL. Catchability may be affected by environmental conditions such as light and current.

## **Appendix P. North Carolina Division of Marine Fisheries River Herring Monitoring Programs (Holly White)**

### **Anadromous Juvenile Survey**

NC Division of Marine Fisheries (DMF) conducted a anadromous juvenile survey from 1972–2015. The primary objective of this survey is to document annual year-class success of all Albemarle Sound anadromous young – of –year. All fish species are enumerated at each sampling station. This survey was used in the 2012 ASMFC River herring stock assessment for only the Chowan River.

### ***Survey Methods***

Seine stations are sampled with a 60 ft bag seine with 0.25 inch mesh bag, with a single haul considered one unit of effort. Trawl stations are sampled utilizing an 18 ft semi-balloon trawl, constructed of 1.5 inch stretched mesh webbing in the body and 0.5 inch stretched mesh in the cod end. Each trawl sample is pulled for 10 minutes (15 minutes for hassler stations), and considered one unit of effort for calculating CPUE. Sampling occurs monthly from June through October.

Stations were selected based on major spawning and nursery areas for striped bass and river herring, which included the western portion of Albemarle Sound, Chowan River and the other tributaries of the Albemarle Sound.

Eleven core seine sites have been sampled since 1972 for juvenile alosines. Through time these sites, at minimum, have been sampled once a month. North Carolina developed a stock status indicator based on these core sites of a catch per unit effort (CPUE) of 60 Blueback Herring young-of-the-year in the Albemarle Sound juvenile abundance survey.

### ***Sampling Intensity***

Although overall stations and intensity has changed since its inception, this program currently consists of 62 trawl and 29 seine stations throughout Albemarle Sound. Stations were standardized in 2005 and monthly sampling for seine sites were increased to two per month to better track juvenile alosine movements.

### ***Biological Sampling***

Juvenile alosines are sorted by species, counted, and a maximum subsample of 30 individuals is measured to the nearest millimeter for fork length (FL), and total length (TL) to determine growth. All other species are enumerated by species and in some cases a subsample (maximum of 30 per station) is measured for FL and/or TL.

Surface and bottom water temperature (°C), dissolved oxygen (mg/L), conductivity (mS), salinity (ppt) and pH are collected using a Yellow Springs Instruments (YSI) meter. Any submerged aquatic vegetation (SAV) collected in the sample is identified to species and/or genus.

### **Spawning Area Survey**

The NCDMF anadromous spawning area surveys are conducted through the Program 150 Adult Anadromous Spawning Area Survey and Program 160 Anadromous Egg and Larval Survey. Surveys have been conducted annually in the Chowan River system in conjunction with one other system in the Albemarle Sound area on a rotating basis since 2008. Prior to 2008, spawning area surveys were conducted sporadically in various systems since 1972 with no consistency. These surveys are necessary to determine which areas are currently functioning as productive spawning areas. These surveys will provide data to determine which areas should be considered for habitat restoration and protection through the Coastal Habitat Protection Plan and stock restoration efforts.

### ***Survey Methods***

Sampling begins at stations closest to the mouth of each tributary. One or more of the following criteria are used to determine an Anadromous Fish Spawning Area (AFSA): (1) the presence of running ripe adult females, (2) the presence of eggs or larval fish, or (3) the visual observance of spawning. To designate a station as a spawning area, a minimum of one of the previous criteria needed to be met. If one of the criteria is met, sampling is continued upstream of the current station to further track river herring migration into tributaries.

Sampling in Program 150 is conducted with short shots (usually 5-10 yards) of monofilament gill net of various sizes (2.5-2.75 inch stretch mesh) and 1.5 inch mesh fish pots at selected stations in each system, usually at bridge crossings. In certain systems gill nets or pots may be set in areas that can only be reached by boat. Adult samples are sorted to species and all individuals of each alosine species present are measured (mm, FL, TL), weighed (kg), sexed, spawning condition is determined, and an ageing sample is taken. All other species are enumerated by species and in some cases a subsample (maximum of 30 per station) is measured for FL and/or TL.

### ***Sampling Intensity***

Ichthyoplankton net tows are conducted from March through mid-May, following evidence of spawning, or used exclusively in areas where adult samples are not conducted. Each plankton net consists of 500 micron mesh encircling a 50 cm wide mouth to a conical length of 150 cm. A collection jar with a 500 micron mesh is attached to the cod end. Surface and mid water tows are conducted if the water depth is greater than 2.0 m. Gear restriction allows the mid water net to be fished to a maximum depth of 2.5 m. The net is deployed and pushed in an upstream direction for five minutes at 1.4 knots. Tributary access points that are too small to sample with a boat mounted larval net are fished from bridge crossings. The net is lowered into the tributary from the bridge and water is allowed to flow through the net for ten minutes.

### ***Biological Sampling***

Larval fish and eggs are sorted by species, counted, and a maximum subsample of 10 individuals is measured to the nearest millimeter TL. All other species are enumerated by species.

Surface and bottom water temperature (°C), dissolved oxygen (mg/L), conductivity (mS), salinity(ppt) and pH are collected using a Yellow Springs Instruments (YSI) meter. Additional habitat and environmental data are collected at each sampling site.

### **Chowan River Pound Net Survey**

The Chowan River pound net survey was implemented in 2008 to provide estimates of CPUE, percent of repeat spawners, as well as size, age and sex data for Alewife and Blueback Herring. These data are necessary to monitor stock status indicators and the overall stock status of river herring in the Albemarle Sound area.

The NCDMF contracts with four commercial pound net fishermen in the Chowan River system to collect river herring samples from their pound nets. A weekly, unculled subsample of adult river herring is obtained from each fishermen's contracted pound nets; the total sample is approximately 20 lb. Sampling includes an estimate of the total daily catch in pounds from all of the pound nets set regardless of whether it was a designated contracted net or not. Total daily catch is estimated from a total of all pound nets set and recorded in a logbook. Alewife and Blueback Herring are counted and sampled to determine length, weight, sex, and spawning condition. Scales and otoliths are taken for ageing. Total pounds and catch rates are estimated for Alewife and Blueback Herring.

## **Appendix Q. North Carolina Wildlife Resources Commission River Herring Monitoring Programs**

**(Jeremy McCargo)**

### **Electrofishing Surveys**

The North Carolina Wildlife Resources Commission (NCWRC) manages river herring populations and establishes regulations within Inland Waters of the state, while the North Carolina Division of Marine Fisheries has authority over river herring management in Coastal Waters. On July 1, 2006, the NCWRC enacted a harvest moratorium for river herring in Inland Waters. Prior to the moratorium, recreational fisheries for bait and personal consumption in Inland Waters consisted of anglers using “sabiki rigs” as well as bow nets and bridge basket nets that were licensed as special devices. NCWRC did not conduct targeted river herring survey programs prior to the announcement of the harvest closure despite the seasonal importance of the recreational fisheries and their associated regulations. Thus, data are limited to a few presence/absence records for years prior to 2006. In spring of 2006 and in response to the impending moratorium, however, NCWRC initiated river herring sampling programs in Inland Waters of major river basins in coastal North Carolina to establish a baseline year for moratorium evaluation. Biologists selected two creeks known to previously support river herring spawning runs in each of four districts, which also loosely correspond to major river basins. River basins sampled for river herring include: the Chowan River Basin and Roanoke/Cashie River Basin within the Albemarle Sound drainage, Tar River Basin, Neuse River Basin, and Cape Fear River Basin (Figure 1). Creeks and sample sites within each basin have varied over the length of the study program, but for the most part, similar sample sites have been surveyed from 2006–2015.

### ***Survey Methods***

River herring sampling is conducted during spring spawning runs using boat-mounted electrofishing gear. Between two and four sample sites are electrofished in each tributary on a weekly basis. Herring are also opportunistically collected during other anadromous species sampling programs in some mainstem rivers. Long-term sample sites have been maintained in most river basins, and exploratory sites are added in additional tributaries each year to determine river herring distribution within a basin.

### ***Sampling Intensity***

Sampling typically begins in late February as water temperature approaches 10°C, continues during optimum spawning temperatures (16–20°C), and ends when spawning appears complete, which is usually in late April or early May. Actual electrofishing time (seconds) is recorded for each sample site.

### ***Biological Sampling***

Each fish collected is identified to species and measured for total length (mm) and weight (g). Sex is determined by applying directional pressure to the abdomen toward the vent and observing the presence of milt or eggs. Relative abundance for each sample is indexed by catch-per-unit-effort (CPUE)



and expressed as number of fish captured per hour. Mean daily and overall CPUE are calculated to compare relative abundance between years. Length frequencies of river herring are reported by species and sex. Ageing structures are not taken. Surface water temperature (°C), dissolved oxygen (mg/L and % saturation), conductivity (µS) and salinity (ppt) are measured at each sampling site, while pH and secchi depth are measured less frequently.

*CPUE Limitations.* River herring abundance can vary widely among sampling trips. Weather related factors like water temperature, precipitation, and stream flow contribute substantially to this variability. However, at low population levels, there is added variability associated with the reduced likelihood of electrofishing gear even encountering river herring. Therefore, caution should be exercised in interpreting these data. CPUE information has the potential to become more meaningful when river herring populations begin to expand and gross increases in abundance are measured.

### **Chowan River Blueback Herring Stocking Project**

The NCWRC began the Chowan River Blueback Herring fry stocking pilot project in 2012. The objectives of the pilot project are to determine the effectiveness of supplemental Blueback Herring stockings and evaluate genetic microsatellite markers for parentage based tagging (PBT) methodology to identify specific cohorts of stocked fish. Endemic broodstock are collected from up to three tributaries of the Chowan River each year. The broodstock are tank-spawned at Edenton National Fish Hatchery, and progeny are stocked back to the stream of broodstock origin at approximately 3 days post hatch. Evaluation of the stocking project is still pending proof-of-concept of the PBT methodology, yet approximately 0.7 million Blueback Herring fry were stocked in 2012, 2.3 million fry were stocked in 2013, and 2.0 million fry stocked in 2014. Fry were not stocked in 2015. However, genetic samples from adult Blueback Herring will continue to be evaluated from the Chowan River study sites as stocked cohorts mature and recruit into returning adults.

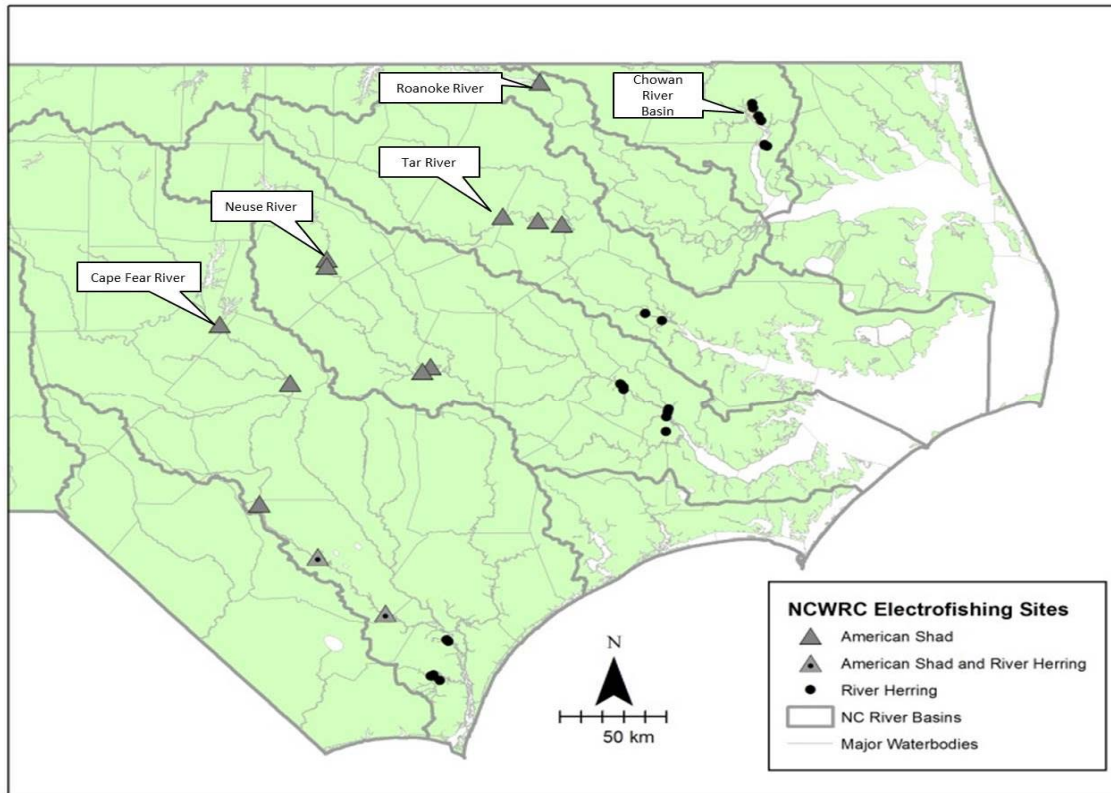


Figure 1. Electrofishing sites used by NCWRC biologists to collect river herring samples in 2014. Additional sites have been sampled in previous years.

## Appendix R. South Carolina Department of Natural Resources River Herring Monitoring Programs (Bill Post)

### Background

In 1938, the South Carolina Public Service Authority (SCPSA) initiated the Santee-Cooper Diversion Project. The project dammed Santee River at river km 143.201 and headwaters of Cooper River creating two reservoirs joined by a canal that diverted Santee River water to Lake Moultrie and the Cooper River for flood control, navigation, and hydroelectric power production. Santee Dam (Wilson Dam), a flood control structure on Santee River (river km 143) created Lake Marion. Pinopolis Dam (river km 77), a hydroelectric facility and navigation lock, impounded diverted water from Lake Marion along with the headwaters of Cooper River to form Lake Moultrie (Figure 1). Unfortunately, this resulted in frequent shoaling in Charleston Harbor, so the decision was made to divert the water back to the Santee River and in the process, construct a hydroelectric plant and ~15km.canal. The resulting Cooper River Rediversion Project, completed in 1985, set a maximum weekly average discharge of 127 cms from Pinopolis Dam, and re-diverted the balance of the flows back to the Santee River, primarily via the St. Stephen Dam and Rediversion Canal. A site-specifically designed fish lock, colloquially known as a fish lift, was also constructed to mediate anticipated declines in anadromous fish passage into the Santee Cooper system via the Pinopolis Lock.

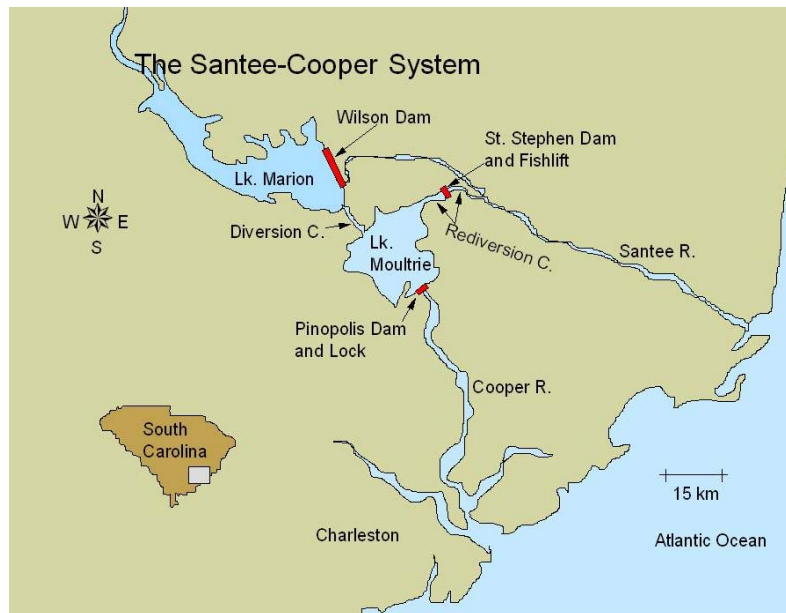


Figure 1. The Santee-Cooper system.

## **Blueback Herring Survey**

As a result of Amendment 2 to the shad and river herring FMP, SCDNR initiated a Blueback Herring Survey for the Santee River in 2008. The primary objective of this survey is to document annual abundance of spawning herring in the Santee River. All fish species are enumerated at each sampling station.

### ***Survey Methods***

Sampling occurs through the use of a 22.86-m drift gill net with 6.35-cm stretch mesh. The study site was selected based on the historic fishery, institutional knowledge, and the ability to sample gear in an effective manner.

### ***Sampling Intensity***

Since 2008 sampling occurred once a week for two consecutive months starting in April. This coincided with the Santee River commercial fishery. Staff shortages precluded sampling from taking place in 2010.

### ***Biological Sampling***

Lengths (FL) and sex was recorded for all captured herring.

### ***Development of Estimates***

Collected data provide annual catch rates and sex specific length histograms as required by Amendment 2 of the shad and river herring FMP.

## **Fish Lift Bio. Sampling**

The St. Stephen fish lock is located approximately mid-way on the Rediversion Canal at river kilometer 92 (Figure 1). Passage for Blueback Herring has occurred at this facility since its inception in 1986.

### ***Survey Methods***

Migratory fish are attracted into the entrance of the fish lock by an attraction flow that is variable to approximately 21 cms and composed of gravity fed and siphon fed (since 2000) components. Fish are forced into the lock chamber that then floods to head level and a brail basket prompts fish to swim up through the water column approximately 15 –20 m, fish then swim into the exit channel where they pass viewing windows before continuing on to the upper Rediversion Canal and Santee-Cooper system. Generally, fish lock operations are made on the hour during daylight periods. When fish densities increase, operations are done every 30 minutes as required.

### ***Sampling Intensity***

The passage season usually occurs Feb-April. During this time, when it is possible and as needed, cleanings of the facility occur each Friday and biological data are collected from up to 50 fish.

### ***Biological Sampling***

The exit channel holding pool area is cleaned as needed to remove debris and accumulated fish. During cleaning events length (FL and TL) and sex data are recorded for select fish species when available.

### ***Development of Estimates***

Collected data provide sex specific length histograms as required by Amendment 2 of the shad and river herring FMP.

### **Fish Lift Counts**

The St. Stephen fish lock is located approximately mid-way on the Rediversion Canal at river kilometer 92 (Figure 1). Passage for Blueback Herring has occurred at this facility since its inception in 1986.

### ***Survey Methods***

Migratory fish are attracted into the entrance of the fish lock by an attraction flow that was variable to approximately 21 cms and composed of gravity fed and siphon fed (since 2000) components. Fish are forced into the lock chamber that then floods to head level and a brail basket prompts fish to swim up through the water column approximately 15 –20 m, fish then swim into the exit channel where they pass viewing windows before continuing on to the upper Rediversion Canal and Santee-Cooper system. Generally, fish lock operations are made on the hour during daylight periods. When fish densities increase, operations are done every 30 minutes as required.

### ***Sampling Intensity***

The passage season usually occurs Feb-April. Monitoring of fish passage was interpreted from hydroacoustic sampling, 1986-1987; real-time human counts, 1988-1994, and from time-lapse video recording from 1994-Present.

### ***Biases***

Passage efficiency at the St. Stephen Dam is unknown and likely varies among years. Poor passage efficiency was demonstrated by Cooke and Chappellear (1992), Cooke and Coale (1997), Cooke and Leach (2000), and Cooke and Leach (2002). Initially, high or intermittent discharges from the St. Stephen Dam on the Rediversion Canal prevented fish from entering the lock. In the 1990s, the SCPSA implemented a flow agreement to improve the fish-lift function, and a series of modifications were completed from 1995 through 2000 that may have increased the efficiency of the fish-lift. Annual variation in attraction flow, turbine discharge and water temperature in addition to fish abundance in the Rediversion Canal alter annual passage numbers of Blueback Herring at this facility.

The number of Blueback Herring that enters the Rediversion Canal from the Santee River varies among years depending on the relative flows in the Rediversion Canal and the Santee River above the canal. In moderate to high flow years, discharge of water from the St. Stephen Dam attracts fish into the

Rediversion Canal. However, in low flow years when limited water is released from the St Stephens Dam, fish may bypass the Rediversion Canal and use the Santee River proper.

### ***Development of Estimates***

Collected data provide annual run counts which are used as a metric when determining whether or not S.C. meets compliance measures outlined in S.C.'s sustainable herring plan.

### **Blueback Herring Commercial Creel**

SCDNR conducts a creel survey for the commercial Blueback Herring fishery on the Rediversion Canal (Santee River). This survey has occurred from 1991–2014. The primary objective of this survey is to document annual commercial catch for Blueback Herring.

### ***Survey Methods***

This is a non-traditional fishery where fishers use various size cast nets below the St. Stephen Dam in order to capture herring for consumption and bait. Blueback Herring landings from the Rediversion Canal are monitored throughout the commercial season (1 March – 30 April). A creel clerk is stationed at Arrowhead Landing below St. Stephen Dam during legal fishing hours (1900-2400h EST, 2000-2400 EDST). Virtually all parties are interviewed at the completion of their trip. The date, catch, gear type, number of fishermen, number of hours fished, and by-catch are recorded for each boat.

### ***Sampling Intensity***

Since 1991, landing were monitored for two consecutive months starting in March.

### ***Biological Sampling***

Length (FL and TL) and sex data are collected from random samples from fishermen. Scales are also collected to obtain annual age distribution information.

### ***Biases***

Exceptions occur during low flow or drought years when the hydroelectric facility at St. Stephen dam does not pass water, thus reducing the attraction flow needed for herring. In such years, herring tend to stay in the main channel of the Santee River, bypassing the Rediversion Canal and continuing to the Santee Dam. During those years, the fishery shifts to the Santee River below the Wilson Dam. A small fishery continues below the Pinopolis Dam on the Cooper River.

### ***Development of Estimates***

Collected data provide total landings, annual catch rates, and age/length distribution.

## **Appendix S. Florida Fish and Wildlife Conservation Commission River Herring Monitoring Programs**

**(Reid Hyle)**

### **FLFWCC American Shad Spawning Stock Survey**

Florida FWC began a project to track the spawning stock abundance of American Shad in 2002. The survey was formalized into a standardized monitoring program in 2006. All *Alosa* species that are encountered in the course of sampling for American shad are collected in the survey. These include American Shad, Blueback Herring, and Hickory Shad. Data were used in a limited way in the state chapter of the 2012 stock assessment but were not included in the overall coast wide assessment.

#### ***Survey Methods***

Fish are collected in 10-minute electrofishing samples along the main channel of the St. John River. Fish are collected by two-dipnetters while the electrofishing boat meanders downstream at a constant speed slightly faster than the ambient current. Relative abundance is reported as geometric mean total catch per 10-minute electrofishing sample. During the pilot phase of the project from 2002 through 2005 haphazard sampling occurring bi-weekly from December to May between river kilometer 285 and 298 and once every six weeks between river kilometer 314 and 378. From 2006 to 2009, bi-weekly random samples (N-10) occurred between river kilometer 279 and 298 and between river kilometer 314 and 358 from January through April. From 2010 to the present bi-weekly sampling occurs between river kilometer 314 and 358 with two peak season sampling events in January/February between river kilometer 279 and 298. Water temperature, dissolved oxygen, and conductivity are recorded at the beginning of each sample transect.

#### ***Sampling Intensity***

The current protocol is for 10 10-minute samples to occur per sampling trip within randomly selected river kilometers in the respective survey areas. Sampling between river kilometer 314 and 358 occurs bi-weekly from January until CPUE for American Shad drops below 10% of the season's peak, usually early April for a total of seven sampling trips and 70 total samples. Sampling between river kilometers 279-298 occurs in two trips during the peak of the American Shad run for a total of 20 samples.

#### ***Biological Sampling***

From 2002-2005, Blueback Herring were returned to the lab where sex, TL, FL, TW, and ovary free bodyweight were recorded. Gonads were processed for histology and scales and otoliths were taken for age. Age analysis was not completed. Sex, TL, and TW were recorded in the field and fish were released from 2006-2010. The current protocol records sex and TL in the field and all herring are released unless retained at the request of outside researchers. Measurement of TW in live specimens was dropped to reduce handling time and because sampling occurs throughout the spawning season and TL/TW weight relationships reflect the spawning condition of specimens at the time of collection more so than size or condition on entering the river to spawn. Therefore it was decided that a numeric index and length size

distribution would be the focus of the survey. Fin clips have been collected for genetics in select years and whole specimens were provided to an outside lab for otolith microchemistry in select years.

### ***Biases***

The survey is structured to measure CPUE, sex ratio, size distribution, and age structure of the American Shad spawning stock. The spawning grounds of Blueback Herring and American Shad overlap such that herring are collected at some point in the sample season in both sample areas. However, the full extent of the Blueback Herring spawning grounds is not known for the St. Johns River and the CPUE of herring in the American Shad survey may not reflect actual herring abundance if there is some primary herring spawning area outside of the American Shad spawning grounds. Exploratory sampling has not detected significant aggregations of Blueback Herring outside of the American Shad samples areas but this remains a possible source of bias.

The American Shad sampling season begins before and ends after the Blueback Herring spawning run so a temporal bias should not exist.

Electrofishing samples should be free of bias with regard to size distribution and sex ratio.

### ***Development of Estimates***

The current CPUE index is calculated as the geometric mean catch per standard sample from February and March sample trips. Calculation of CPUE from years prior to 2010 should be limited to samples collected in months and locations that are part of the current standardized program, e.g. February/March and between river kilometer 279 and 358.



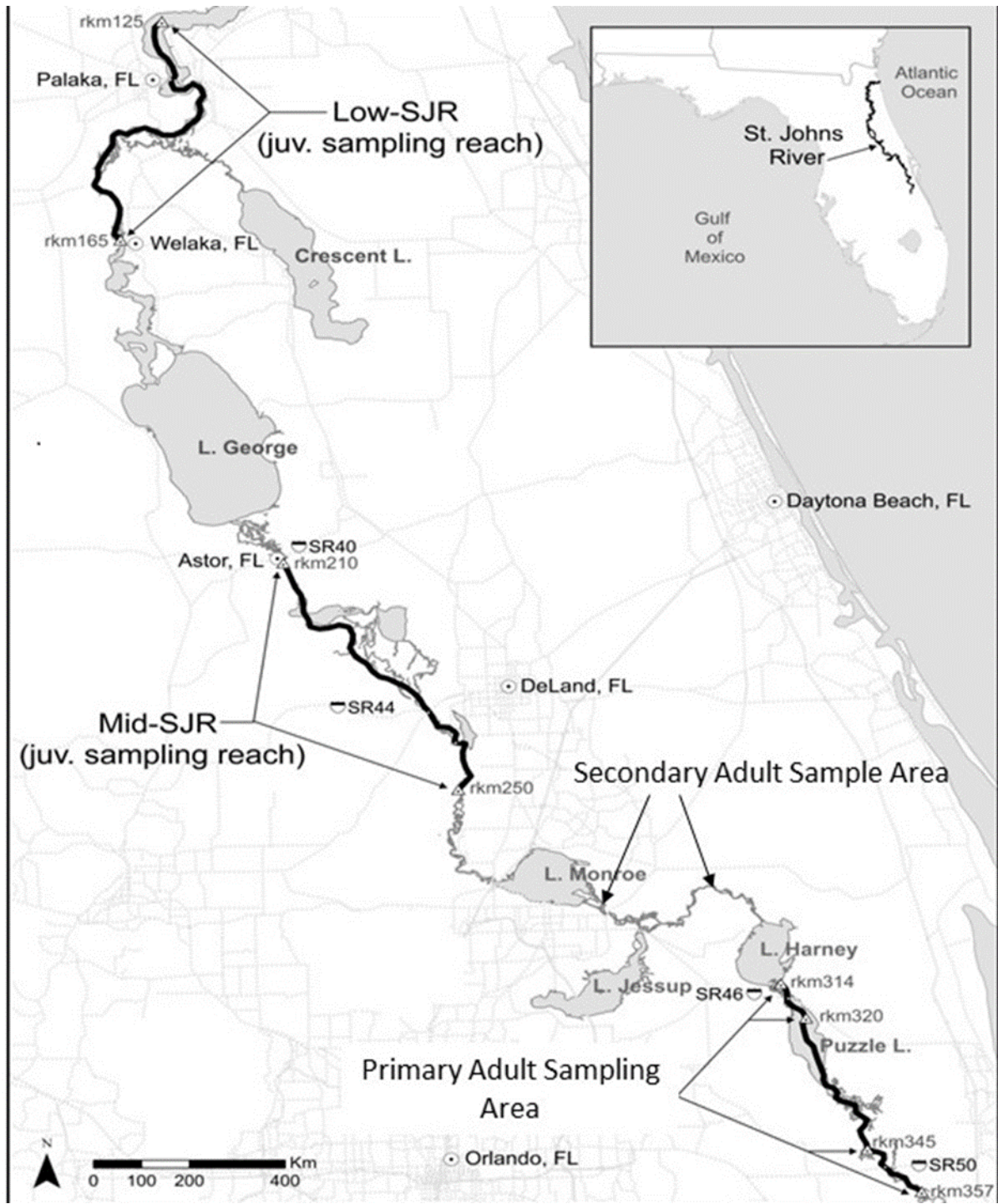


Figure 2: Sample areas for *Alosa* species in the St. Johns River, Florida.

## **FL FWCC St. Johns River Juvenile Alosa Survey**

Florida FWC began tracking the relative abundance of juvenile *Alosa* species in the St. Johns River Nursery zone beginning in 2007. The pilot study ran from 2007 through 2009. A standardized monitoring program was implemented beginning in 2010. Data were used in a limited way in the state chapter of the 2012 stock assessment but were not included in the overall coast wide assessment.

### ***Survey Methods***

Juvenile abundance of *Alosa* species in the St. Johns River, Florida is assessed annually as the geometric mean catch per tow by bow mounted push net. The sample gear is a 5.5 m aluminum boat used to push a modified four panel Cobb trawl mounted on a rigid frame. The net opening is 1.2 m high X 1.5 m wide. The body is 3 m deep and constructed of 19 mm stretched mesh knotless nylon. The cod end is 2 m deep and constructed of 12.7 mm stretched mesh knotless nylon. All *Alosa* are placed on ice and returned to the lab for identification, enumeration, and measurement of total length. By-catch are identified and enumerated in the field. Environmental data collected at each station comprise water temperature, dissolved oxygen, and conductivity. River discharge and tide information are obtainable from USGS gages at river kilometers 150, 209, and 236.

Development of this index began in 2006. The gear was tested in 2006 and limited CPUE data are available from the haphazard sampling that occurred in that year. From 2007 through 2009 an attempt was made to document the timing of migration of juveniles through the river in order to select reaches for annual monitoring. The nursery zone was sampled monthly from March or April to October. Sampling consisted of 48 five-minute tows at randomly selected stations between Warner Point and Lake Harney which corresponds to river kilometers 125 and 305 with sampling occurring at 12 stations each on four consecutive nights. Juveniles were distributed throughout this 180 km area from late April through mid-summer under conditions of low discharge. Most juveniles transitioned to below river kilometer 200 into tidal freshwater by early summer under conditions of high discharge. Two representative index reaches have been selected; one in the river run (Middle SJR) above the tidal zone between river kilometer 210 and 250 and one in tidal freshwater (Lower SJR) between river kilometer 125 and 165. Index sampling occurs by-weekly beginning in late March in the Middle SJR and in late April in the Lower SJR. Sampling continues until the nightly average American Shad CPUE drops below 10% of the season's peak.

### ***Sampling Intensity***

There are 12 samples collected every two weeks in each 40-kilometer reach for the duration of the sample season. This results in 60-96 samples per stratum per year depending on the rate at which juvenile *Alosa* species move downstream through the sampling strata.

### ***Biases***

Sampling prior to 2010 was monthly whereas sampling from 2010 onward is bi-weekly.

The effect of the emigration rate on local abundance can affect the ability of CPUE to reflect actual population abundance. We have not determined whether the Middle SJR stratum or Lower SJR stratum provides a superior index or if a combined index would be preferred.

Also, sampling is terminated when CPUE of American Shad drops below 10% of the seasonal peak in nightly average CPUE but this may not always coincide with the same for Blueback Herring.

### ***Development of Estimates***

The calculation of JAI from this survey has not been finalized. It is noted that frequency of sampling increased in 2010 whereas the area sampled was narrowed which may limit the ability to compare CPUE across dates in this short time series.

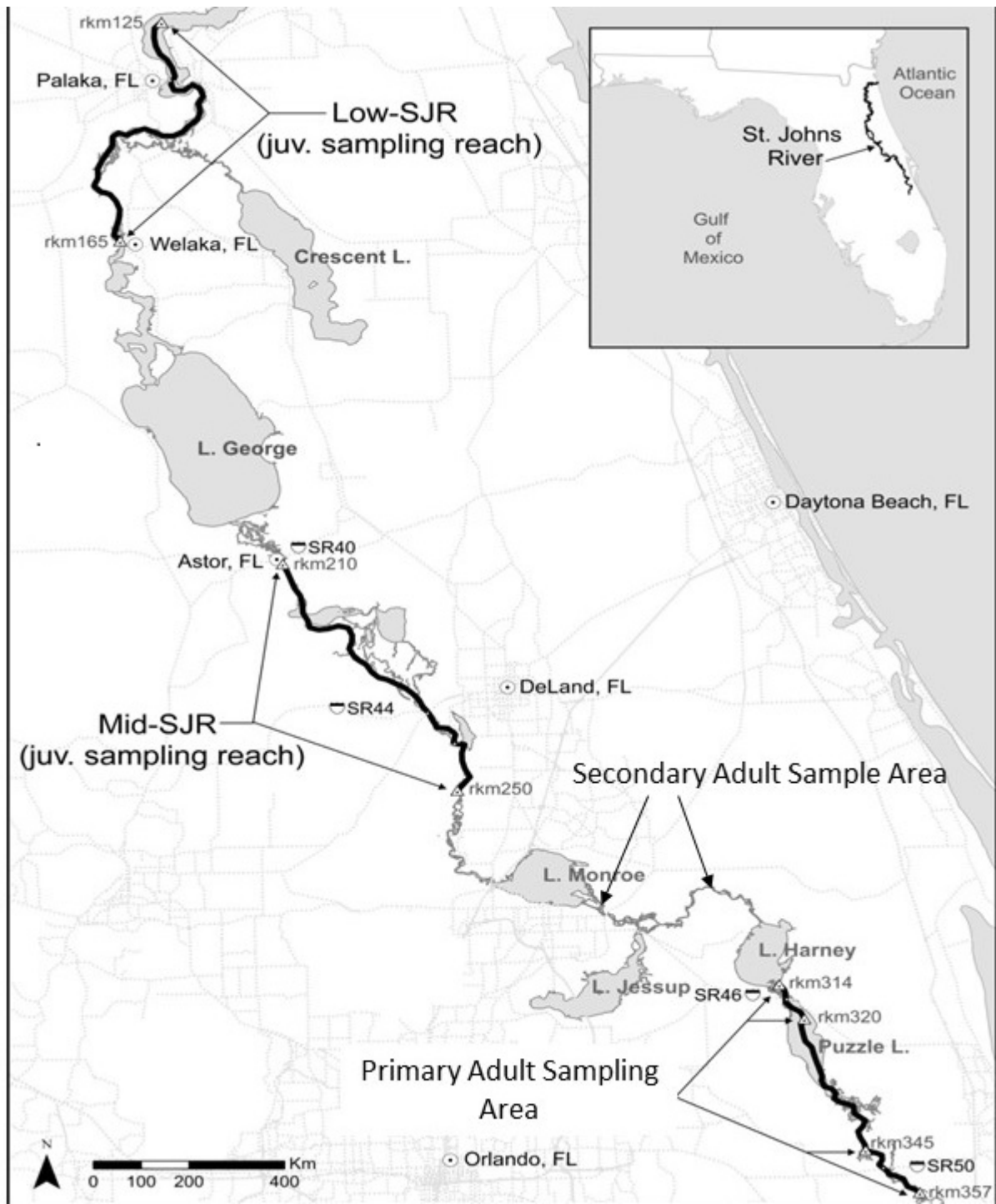


Figure 3: Sampling areas for *Alosa* in the St. Johns River, Florida.

## Appendix T. Guidelines for genetics sample collection

### Fresh fish (Blotting paper protocol)

*In the field:* Cut a small (0.3 – 1 cm<sup>2</sup>) clip from the **caudal or anal** fin using scissors. Place fin clip on the inside of the folded piece of dry blotter paper. Fold blotter paper over and with two fingers lightly squeeze fin clip. Place blotter paper with fin clip in coin envelope but do not seal the envelope. Samples from each fish must be stored in a separate envelope. On the coin envelope, please include: species, date, location, total length, and sex (if possible). Between fin clips, rinse scissors with water and wipe clean to avoid cross-contamination. Don't seal envelopes yet.

*At the office:* Fin clip samples must be air-dried as soon as possible (don't wait more than 8 hours) to maintain high quality of the DNA. Air-drying indoors takes 24-48 hours. Samples can also be air dried in the sun. It is best to remove the blotter paper from the envelope and place on top of the envelope (or otherwise take measures to avoid mixing up samples) and then wait until the blotter paper is dry to the touch. When blotter paper is dry to the touch, place paper with clip back into envelope and seal the envelope. Store envelopes in a plastic bag, it is important that the fins don't get wet again. Please do not store samples in a plastic bag until after they are fully dry.

### Frozen fish (EtOH protocol)

It is best to store tissue from frozen fish in ethanol. We have not provided tubes with ethanol, but if you are working with frozen fish, please let us know and we can send you the supplies. Cut a small (*i.e.*, 1cm<sup>2</sup>) fin clip from **caudal** fin of the frozen individual (do not let it thaw; thawing destroys DNA) using clean scissors and place in a vial filled with 95% EtOH. Sample must be fully immersed in EtOH. Place a small piece of paper with Sample ID written in pencil inside the tube. Ethanol dissolves all inks, so make sure pencil is used. Vials need to be well sealed to avoid evaporation.

**-Each sample must be stored in a separate envelope/vial**

**-Each sample must be clearly labeled with the Sample ID number**

### Literature Cited

Palkovacs, E.P. 2015. Lab Protocol: Tissue collection and shipping for genetic analysis.

## Appendix U. Meeting Agenda

### Atlantic States Marine Fisheries Commission River Herring Data Collection Standardization Meeting

November 18-20, 2015

*The Sheraton BWI  
1110 Old Elkridge Landing Road  
Linthicum, MD 20190;  
443-577-2100*

#### **Wednesday, November 18 (1:00 pm – 5:00 pm)**

1. Welcome and Introductions (*K. Rootes-Murdy*)
2. Goals and Objectives of Workshop (*K. Rootes-Murdy*)
3. Review of State, Federal, and Tribal Survey Programs (*TC members/Participants*)
4. Public Comment

#### **Thursday, November 19 (8:30 am – 5:00 pm)**

1. Review of State, Federal, and Tribal Survey Programs (cont'd)
2. Fishery dependent data
3. Standardization approaches presentation and discussion (*ASMFC Staff*)
  - a. Survey design (*ASMFC Staff*)
  - b. Survey data (*ASMFC Staff*)
  - c. Recommendations (*ASMFC Staff*)
4. Public Comment

#### **Friday, November 20 (8:30 am – 3:00 pm)**

1. Standardization approaches presentation and discussion (cont'd)
  - Prioritize changes to surveys
2. Data Limited Approaches to stock assessments (*ASMFC Staff*)
  - Data Considerations (*ASMFC Staff*)
  - Data Limited Approaches (*ASMFC Staff*)
3. Next Steps: 2017 ASMFC assessment and implementation (*ASMFC Staff*)
4. Public Comment
5. Adjourn

# Appendix V. Decision Tree for Run Count Surveys

