Quality Assurance Project Plan for Alewife Monitoring in the Peconic Estuary 2020-2024

1Photo Credit Byron Young

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Prepared by:
Peconic Estuary Partnership
Riverhead County Center
300 Center Drive, room 204N
Riverhead, NY 11901

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New England Interstate Water Pollution Control Commission (NEIWPCC)
Lowell, MA

USEPA Region 2
290 Broadway
New York, NY 10007

Approved By:

Elizabeth Hornstein Project Manager Peconic Estuary Partnership	Elizabeth Hornstein 2020.08.24 13:29:34 -04'00'	
Joyce Novak, PhD Director Peconic Estuary Partnership	Joyce Novak	8/24/20
Heidi O'Riordan Regional Fisheries Manager NYSDEC Region 1		6/30/2020
Peter Zaykoski Quality Assurance Program Manager NEIWPCC		5/5/2020

Aimee Boucher _____ 05/05/2020
Watershed Management Branch
USEPA

Omer Sohail _____ 05/05/2020
QA Officer
USEPA

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Joyce Novak, PhD
Director, Peconic Estuary Partnership
Riverhead County Center
300 Center Drive, Room 204N
Riverhead, NY 11901
Joyce.Novak@suffolkcountyny.gov
(631) 852-2961

Elizabeth Hornstein
State Coordinator, Peconic Estuary Partnership
NYSDEC, Division of Marine Resources
205 North Belle Meade Road, Suite 1
East Setauket, NY 11733
elizabeth.hornstein@dec.ny.gov
(631) 444-0871

Sarah Schaefer
Program Coordinator, Peconic Estuary Partnership
Riverhead County Center
300 Center Drive, Room 204N
Riverhead, NY 11901
Sarah.Schaefer@suffolkcountyny.gov
(631) 852-5806

Byron Young
Retired NYSDEC Biologist
youngb53@optimum.net

Heidi O'Riordan
Regional Fisheries Manager
NYSDEC Region 1
50 Circle Rd
Stony Brook, NY 11790
heidi.oriordan@dec.ny.gov
(631) 444-0281

John Maniscalco
Bureau Chief of Marine Fisheries
NYSDEC Division of Marine Resources
205 North Belle Meade Road, Suite 1
East Setauket, NY 11733
john.maniscalco@dec.ny.gov
(631)444-0437

Peter Zaykoski
NEIWPCC Quality Assurance Program Manager
650 Suffolk Street, Suite 410
Lowell, MA 01854
pzaykoski@neiwpcc.org
(978) 349-2526

Alexandra Morneau
NEIWPCC QA Receiver
650 Suffolk Street, Suite 410
Lowell, MA 01854
qapps@neiwpcc.org
978-349-2502

Emma Gildesgame
NEIWPCC Program Manager
650 Suffolk Street, Suite 410
Lowell, MA 01854
egildesgame@neiwpcc.org
(978) 349-4318

Aimee Boucher
Watershed Management Branch
New York Watershed Management Section
290 Broadway, 24th floor
New York, NY 10007
boucher.aimee@epa.gov
(212) 637-3837

Omer Sohail EPA QA Officer
Monitoring and Assessment Branch US EPA Region 2
2890 Woodbridge Ave., MS-220 Edison, NJ 08837
sohail.omer@epa.gov
(732) 321-6785

A4. Project/Task Organization

Elizabeth Hornstein of Peconic Estuary Partnership (PEP) will serve as the Project Manager and be responsible for maintaining the official, approved QA Project Plan. She will coordinate monitoring activities under this Project Plan, supervise interns/volunteers conducting monitoring activities, validate the data generated from this project, and be responsible for report generation.

Byron Young, retired New York State Department of Environmental Conservation (NYSDEC) biologist, will lead the biological monitoring of alewife on the Peconic River, assist with technical reviews and report generation.

Sarah Schaefer, of Peconic Estuary Partnership, will assist with monitoring activities, technical reviews and report generation. She will also be responsible for participation in meetings and communication with the United States Environmental Protection Agency (USEPA).

Joyce Novak, PhD, Director of Peconic Estuary Partnership will be responsible for overseeing this project for PEP, participation in meetings and communication with the USEPA.

Heidi O'Riordan, Regional Fisheries Manager of NYSDEC Region 1, will be responsible for approving all monitoring activities and technical reviews of the generated data.

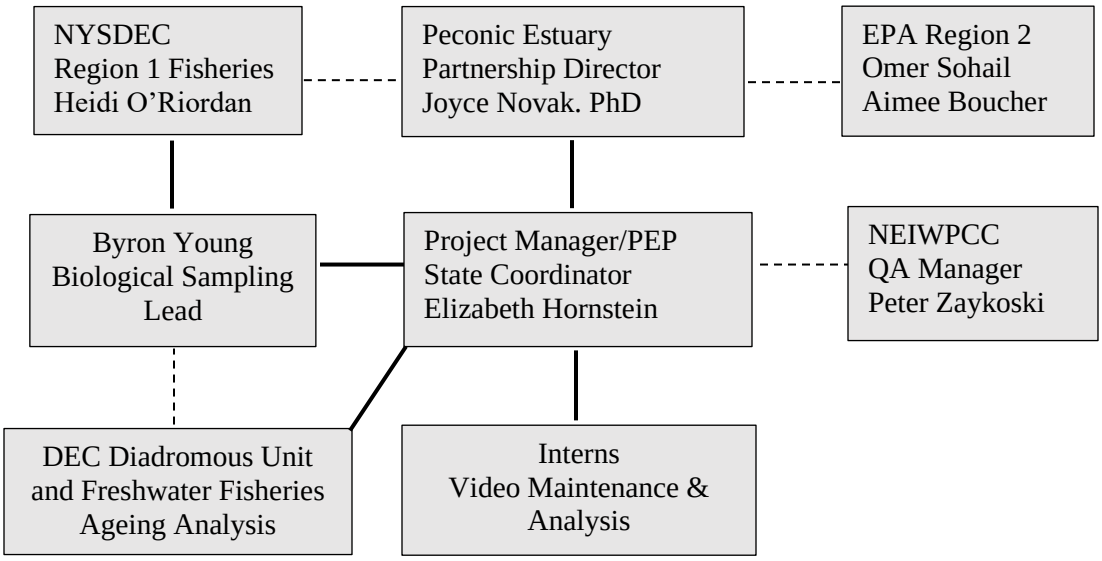
Peter Zaykoski, NEIWPCC Quality Assurance Program Manager will be responsible for review and approval of the QAPP, including all subsequent versions.

Omer Sohail will serve as the USEPA Quality Assurance Officer and will be responsible for review and approval of the QAPP, including all subsequent versions, and participation in Agency reviews of work performed.

Aimee Boucher, Clean Water Division, USEPA, Region 2, will participate in technical reviews and internal PEP communication of results.

Project Organization Chart

Solid lines are authority, dotted lines are communication



A5. Project Definition/Background

Alewives (*Alosa pseudoharengus*), one of two species collectively referred to as river herring, are a diadromous fish that spend most of their lives in the Atlantic Ocean off the coast of Maine and Canada but enter freshwater tributaries along the east coast of the United States in the spring to spawn. Alewives have been found spawning in tributaries from the Canadian Maritime to the Carolinas. The spawning run in New York usually lasts from late February through mid-May. Juvenile alewives grow throughout the summer in the freshwater environment before heading back out to the estuary and return to the ocean by age one. Alewife reach sexual maturity around 3-4 years of age and adults average around 12 inches in length. Alewives play a significant ecological role in ocean, estuary, and freshwater systems. During their journey from ocean to freshwater, they serve as a high energy food source for numerous predators including whales, dolphins, seals, tuna, striped bass, herons, osprey, otters, and raccoons. Their movement from salt to fresh water is especially important in transferring ocean-derived energy into estuarine, freshwater and upland habitats.

Unfortunately, alewife population numbers have declined in recent decades due to overfishing, bycatch, poor water quality, and the creation of impediments to spawning ground access, such as dams. The construction of dams on nearly all Long Island's freshwater tributaries in the late 1800's and early 1900's cut off historic migratory routes for alewife and other local diadromous fish. Poorly designed road culverts have also blocked access to freshwater habitats for alewife. Since alewives are not equipped for jumping, they tend to have difficulty surpassing barriers as small as 1-2 feet in height.

Over the last several decades there has been a concerted effort by the Peconic Estuary Partnership (PEP) and many other organizations, including the Long Island Sound Study, Seatuck Environmental Association and New York State Department of Environmental Conservation (NYSDEC) to monitor tributaries across Long Island to determine where remnant runs of spawning alewife remain and to advance river connectivity and fish passage projects to benefit diadromous, migratory fish runs. The Peconic Estuary is one of 28 estuaries across the nation recognized by the US Environmental Protection Agency as an "Estuary of National Significance" and the Peconic Estuary Partnership, a partnership of local, state, and federal governments, citizens, environmental groups, businesses, industries, and academic institutions, is supported under Section 320 of the US EPA Clean Water Act. Restoring access to freshwater diadromous fish habitat aligns with the PEP's Comprehensive Conservation and Management Plan and is a priority in the PEP 2017 Habitat Restoration Plan. Additionally, in 2018, Seatuck Environmental Association, with support from PEP and Long Island Sound Study, published a Long Island Diadromous Fish Restoration Strategy that lays out lofty goals for restoring Long Island's alewife populations.

The two largest alewife spawning runs on Long Island occur in the Peconic Estuary watershed. Alewife Creek supports the largest alewife run and is the only unobstructed run on Long Island. The Peconic River, the longest river on Long Island, supports the second largest alewife run but has several barriers to diadromous fish passage. Due to the importance of the Peconic River for alewife spawning habitat, restoration efforts have been heavily focused on this river over the last decade.

Previously, the Peconic River had six dams along its length that prevented alewife and other diadromous fish species from migrating up and downstream. In 2010, a permanent nature-like fishway was built at the Grangebel Dam, the first barrier on the Peconic River, opening up 25 acres of freshwater habitat to diadromous fish. In 2016, when repairs were made to the Edwards Avenue Dam, the fourth barrier on the mainstem of the Peconic River, a fish passage was also installed. Alewife cannot yet access this fish passage due to downstream barriers at the Forge Road and Upper Mills Dams, but PEP is working with its partners on fish passage projects at both barriers. PEP is also working in partnership with Suffolk County Parks to install a combination denil pass and step pool fish passage and eel passage through the Woodhull Dam, on the Little River, a major tributary to the Peconic River. Currently, the majority of the alewife population that uses the Grangebel fishway has been observed to end up at Woodhull Dam, spawning below the dam each year in a stalled effort to reach upstream habitat. Providing permanent fish passage at Woodhull Dam will create access to 95 acres of prime spawning and maturation habitat within the preserved lands of Wildwood Lake and Cranberry Bog Preserve. Once all these fish passage projects are completed, over 300 acres of diadromous fish habitat will be restored in the Peconic River system (Figure 2).

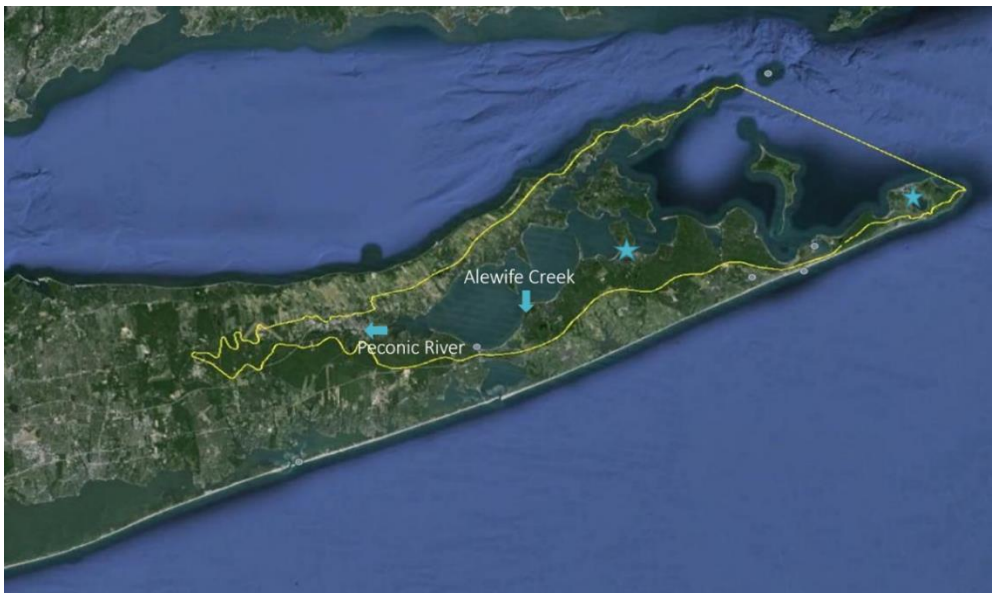


Figure 1 – Location of alewife Spawning Runs in the Peconic Estuary Watershed. The two largest alewife spawning runs on Long Island occur in the Peconic Estuary watershed – in Alewife Creek and the Peconic River. The presence of alewife has also been confirmed at Ligonee Brook in Sag Harbor and Lake Montauk in East Hampton – indicated by the blue stars.

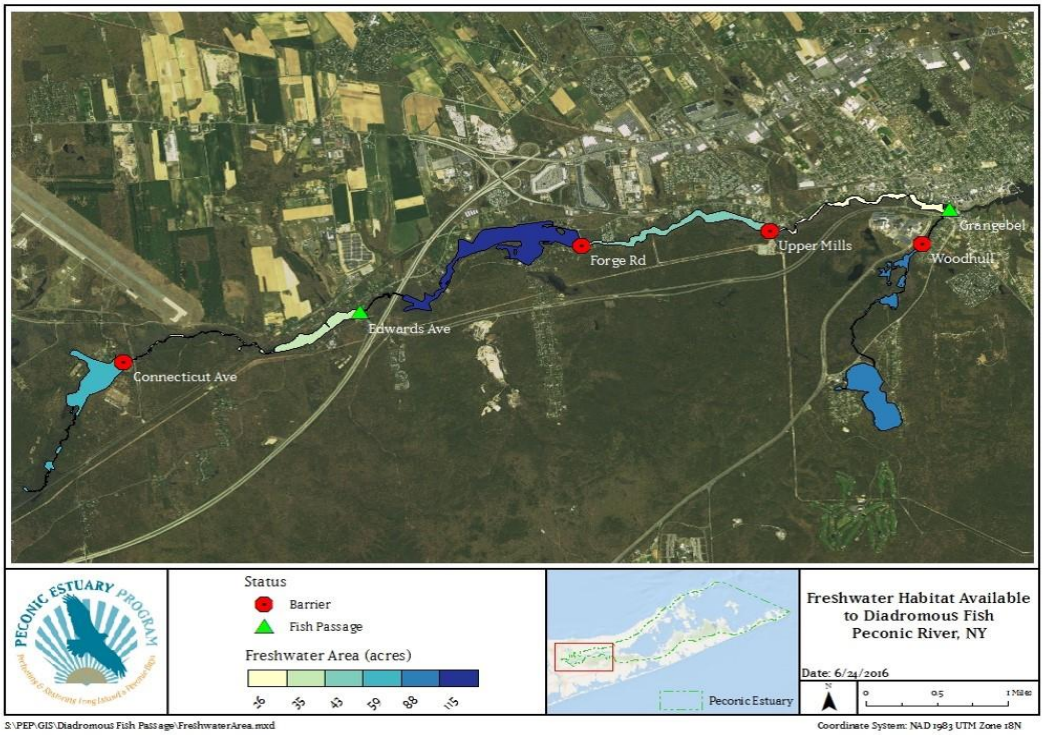


Figure 2- Peconic River Dams and Fish Passage Projects

Alewife monitoring programs are crucial for evaluating the success of restoration efforts and determining stock size. Following the installation of the fishway at Grangebel Park in 2010, a Volunteer Alewife Monitoring Program was initiated on the Peconic River by retired NYSDEC biologist, Byron Young, and is ongoing. This monitoring includes visual estimates of total fish numbers attempting to access Woodhull dam and biological sampling, including size measurements, determination of sex, and scale retrieval for age estimates (Young 2019). In the spring of 2019, a 950 Sea-Drop Analog Camera by SeaViewer was installed at the Grangebel fishway on the Peconic River to provide a more robust estimate of the number of alewife using this fishway and coming up the Peconic River and Little River to spawn. This pilot project demonstrated that video footage can successfully be obtained at the Grangebel fishway and used to estimate alewife spawning abundance (Andrescavage 2019). PEP plans to install this camera again at the Grangebel fishway in 2020. Additionally, it is anticipated that a an underwater camera with white lights, along with a steel job site box that will house a laptop to store the recorded footage (exact makes and models TBD) will be installed during the construction of the Woodhull fish passage on Little River in winter 2020/2021 to help evaluate the success of the fish passage project. These video monitoring systems will allow biologists to identify and enumerate species ascending and descending the fishways, to determine fish passage utilization. It will also enable biologists to track abundance of alewife in the Peconic River over time and determine if the population is increasing as a result of restoration efforts. The collection and analysis of the video monitoring data will be led by existing PEP staff, with assistance from interns, academic partners and NYSDEC. As additional fish passage projects are completed on the Peconic River and around the Estuary, monitoring may be expanded to other locations.

This Quality Assurance Project Plan (QAPP) formalizes a process for analyzing video footage to obtain fish abundance estimates. This QAPP also formalizes procedures for collecting visual fish count data and biological data. This data will be provided to the New York Department of Environmental Conservation and the Atlantic States Marine Fisheries Commission to aid in stock assessments and the management of alewife.

A6. Project/Task Description

The primary goal of this project is to estimate alewife spawning abundance in the Peconic River and in the future other tributaries in the Peconic Estuary watershed. Abundance data will be used by the Peconic Estuary Partnership and our partners to evaluate the success of fish passage restoration efforts. Additionally, the data will be provided to the New York Department of Environmental Conservation and the Atlantic States Marine Fisheries Commission to aid in stock assessments and the management of alewife.

Various means may be used to monitor the alewife population:

Visual Counts:
Visual counts may be conducted at fishways or narrow passageways in clear, shallow water where all fish pass through a visible point, or in clear, shallow water pools at the base of a dam. Visual counts will be conducted by volunteers trained at a workshop led by PEP Staff. Volunteers will

inspect or watch a site for fixed durations of time and then make an estimate of how many fish were present. Visual counts can be extrapolated to provide an overall daily or weekly abundance estimate. Visual counts will be used to as means to collect initial relative abundance estimates for a tributary and/or to confirm the success of an installed fishway.

Video monitoring:
Video monitoring systems may be installed at fishways or passageways (e.g., natural bottleneck, weir) where all targeted species pass in front of the camera and visibility is adequate. Video monitoring typically provides a more robust estimate of alewife abundance. Trained interns/volunteers watch the recorded video footage to count the number of alewives that passed by the camera. To reduce the amount of video footage that needs to be watched, a random subsampling method will be used, whereby a set number of video segments are watched per day, and count numbers are then extrapolated to provide a daily estimate. In the future, we may also explore using a software, like Salmonsoft that records video only when fish are detected, and then counting all fish detected.

Biological monitoring:
Ongoing biological monitoring of the alewife population, including size measurements, determination of sex, and scale retrieval for age estimates, will continue to occur, as feasible. Cast nets, dip nets, or hand harvesting may be used to capture adult alewife. After measurements are made, the fish are released. A small subset of fish (up to 20/year) may be sacrificed for paired otolith and scale age analysis to evaluate the precision of these two ageing methods.

Current monitoring will be focused in the Peconic River, at the Grangebel Park Fishway and Woodhull Dam (refer to Figure 2). Grangebel Park is located at the intersection of Peconic Ave and Heidi Behr Way in Riverhead, NY 11901. Grangebel Dam, located within the park, is the first barrier the Alewife encounter during their spawning run throughout the Peconic River. In 2010, a permanent rock ramp was built that allows fish to bypass the dam and make their way into the pool on the other side (Figure 3). In spring 2020, a 950 Sea-Drop Analog Camera by SeaViewer, along with a site job box that holds the equipment connected to the camera, including the SD cards and a screen showing the live camera footage, will be installed at the Grangebel Dam fishway to record the number of alewives using the fishway. PEP Staff and interns will clean the camera to keep it free of debris and retrieve the SD cards with the recorded video footage at least twice per week. The Woodhull Dam, located on Little River, a tributary to the Peconic River. is located at 300 Center Dr S, Riverhead, NY 11901. Most of the fish that use the Grangebel fishway head up Little River until they reach Woodhull Dam. At this site there is a pool below the dam where the Alewife end up spawning, since they cannot overcome the dam to continue to their desired upstream habitat (Figure 4). Alewives in the pool below Woodhull Dam are easily captured with a cast net for biological sampling. Biological sampling and visual abundance estimate of alewife at Woodhull Dam will continue in spring 2020. In winter 2020/2021, an underwater camera with white lights and steel job site box that will house a laptop to store the recorded footage (exact makes and models TBD) will be installed during the construction of the Woodhull Dam fishway. Video monitoring at Woodhull Dam is expected to begin in spring 2021 to record fish utilizing the newly constructed fishway. PEP staff and interns will clean the camera and retrieve/download the recorded video footage from the laptop at least twice per week.

Yearly reports will be produced to summarize the Peconic Estuary alewife monitoring efforts and results. The Peconic Estuary Alewife Monitoring Program will be reviewed annually. Monitoring may be expanded to other locations in the future, based on need and available funding. If updates or changes are required to the monitoring plans and methods described in this QAPP, they will be described in a memo and included in an updated QAPP, which will be provided to all personnel on the distribution list. If any signatory to the QAPP indicates that a full review process is appropriate based on the changes, the QAPP will submitted as an amendment for review through NEIWPCC and EPA. Table 1 provides a summary of the project tasks and schedule.

Figure 3- Grangebel Park Ramp (left) and Pool below Woodhull Dam (right)

Table 1: Project Task Schedule

Task	Date Undertaken
Video Monitoring at Grangebel Park Fishway	Annually March 1-May 15, beginning in 2020
Video Monitoring at Woodhull Dam Fishway	Annually March 1-May 15, beginning in 2021
Biological Sampling of Alewife in the Peconic River system	Annually March 1-May 15, as feasible
Data Analysis	Annually, May-August
Report Synthesis	Annually, September-December
Review and adjustments to monitoring plan/QAPP as needed	Annually in January
Re-authorization of QAPP every 5 years	Beginning 2025

A7. Quality Objectives and Criteria

The primary goal of this project is to estimate alewife spawning abundance in the Peconic River

and in the future other tributaries in the Peconic Estuary watershed and collect baseline biological data on alewife. Collecting accurate, precise, representative, complete, and comparable data that will be accurately transferred to a computer database without error will be of the utmost priority. To accomplish this, quality assurance checks will be implemented throughout the project. Data will be collected using various methods and equipment.

A7.1 Precision, Accuracy and Bias:

Visual Counts:
The quality of visual data can be highly variable due to factors such as non-random sampling, site conditions, counter experience and ability, run timing, and visual conditions. While efforts will be made to randomize sampling during daylight hours, obtaining visual estimates at night is generally not possible. All volunteers will be trained through a volunteer alewife monitoring training workshop, led by PEP Staff and experienced biologists, prior to beginning any sampling.

A potential bias with visual counting is milling, or fish moving around in a confused mass; they may move upstream in a group, go downstream and back upstream several times a day or within the season. This can lead to double counting. PIT tagging currently being conducted on the Peconic River by Hofstra University professor Peter Daniel indicates that some alewives do fall back downstream and then head upstream again. This pattern has also been documented in the Carmans River on the south shore of Long Island (McCartin 2019). Once the Peconic River PIT tagging study is complete, a correction factor will be determined, based on the percentage of fish found to oscillate between the lower reaches of the Peconic River and upstream spawning ground habitat, and applied to all count estimates on the Peconic River and other Peconic Estuary tributaries.

Due to the various issues with visual estimates, they will be used to obtain first-order or relative abundance only.

Video Counts:
Video counts can be highly accurate, if water clarity is good, and the counter has the proper experience and training. Recorded video footage will be retrieved/downloaded at least twice per week and analyzed by PEP staff and interns. All interns/volunteers will be trained on how to identify and count alewife by an experienced biologist. Additionally, a subset of the video recordings will be watched by Elizabeth Hornstein, Project Manager, to verify fish counting accuracy. Watching the entire video frame will produce the most accurate and precise abundance estimate but requires a significant amount of time. Programs like Salmonsoft may be used to record video only when fish are present, thereby reducing the amount of video that needs to be watched but introduces added costs. Another option is using a random one-way or two-way stratified sub-sampling design whereby a certain number of randomly generated time intervals is watched each day (e.g., twenty 10-minute intervals), and then the count number is extrapolated to come up with a total daily fish estimate, as described in Nelson et al. 2006. If the sample size (number of time intervals) is high enough, this will still produce a precise and accurate abundance estimate. The pilot

monitoring in 2019 indicates that a minimum of twenty 10-minute time intervals, or a total of 200 minutes, watched per day, should provide for a sufficiently precise abundance estimate (Proportional Standard Error =0.1).

As with visual counts, milling is a potential source of bias. A correction factor will be determined, as described above, and applied to all abundance estimates to account for this bias.

Biological Monitoring:
Biological sampling should be conducted proportional to the abundance metric to achieve desired precision of biological parameters. Biological measurements are currently made on roughly 1.5-2% of the current estimated Peconic River alewife population. Volunteers will be trained by an experienced biologist prior to participating in biological sampling, and any monitoring will always be overseen by a trained biologist to ensure accuracy. Length measurements will be made to the nearest millimeter and weight measurements to the nearest gram. Scale and otoliths samples will be analyzed by trained biologists and technicians at the NYSDEC Marine Resources Diadromous Fish Unit or NYSDEC Freshwater Fisheries Unit using the River Herring Ageing SOP in Appendix C. All scales and otoliths will be examined by a minimum of two agers. Disagreements will require analysis by a third ager. Metrics will be finalized when two of the three agers agree. If no agreement occurs, the sample (and associated fish) will be removed from aging analysis. Otoliths may be removed and aged from a small sub-sample of scarified fish (up to 20 fish/year) and will be compared to scale age estimates from the same fish to identify any differences and evaluate precision. There is currently no validated ageing method for alewife. Many consider otoliths to be more precise and presumably more accurate than scales, but using otoliths requires sacrificing the fish. All monitoring reports will clearly note the structure used for the age estimates and that ageing methods have not yet been validated.

A7.2 Completeness:

Visual Counts:
Completeness will be determined by sampling effort – i.e. number of days monitored and number of times per day. In most cases visual counts are unlikely to occur frequently enough to produce a complete abundance estimate and will be used to obtain relative abundance only.

Video Counts:
Completeness will be determined by the amount of video watched and analyzed. Since resources will likely not allow for the entirety of the recorded video to be watched, a stratified random sub-sampling design will be chosen, as outlined in Nelson et al. 2006, to ensure counts estimates provide a reliable abundance estimate. A minimum of twenty 10-minute time intervals, or a total of 200 minutes, will be watched per day.

Biological Monitoring:
Completeness will be determined by the number of alewives for which biological

parameters are measured. The current target for size measurements on the Peconic River is 600 fish per spawning season. This represents roughly 1.5-2% of the current estimated population. Scale samples are taken from every third fish (roughly 200 fish). Scales have not been analyzed since 2013 due to a lack of available resources. The DEC Marine Resources Diadromous Fish Unit will analyze new scales from 2020 onward and to analyze the back-logged scales from 2014-2019.

A7.3 Comparability

Visual and Video Counts:

Visual count estimates of alewife on the Peconic River have occurred since 2010. Year to year comparisons can provide information on relative abundance fluctuations from year to year. Video count estimates of alewife on the Peconic River will be used to provide more robust estimates of abundance. It is intended that the video monitoring will occur annually on the Peconic River moving forward, allowing for the detection of future abundance changes as further restoration projects are completed. Video monitoring will be conducted at multiple sites on the Peconic River to determine the number of fishes passing through the various fishways, including the number of alewives passing through the first fishway on the River, and the number of alewives heading up Little River vs the mainstem of the River. A standard video analysis procedure will be adopted to ensure comparability among sites.

Biological Monitoring

Future biological monitoring will be compared with historical biological measurements. Length measurements for alewife are available from 1995-1996 and 2010-2019. Length ranges and averages have remained stable throughout this time period. Age data is currently available for 2011-2013.

A7.2 Representativeness

Visual Counts:

Every effort will be made to make consistent visual counts (at least 3 times a week per site) throughout the course of the alewife spawning season.

Video Counts:

Since resources will likely not allow for the entirety of the recorded video to be watched, a stratified random sub-sampling design will be chosen, as outlined in Nelson et al. 2006, to ensure counts estimates provide a representative abundance estimate of the alewife spawning population. Because alewife typically migrate at certain times of the day, a two-way stratified random sub-sampling design will be used in most tributaries, whereby the day is divided into periods and then a randomly generated number of time intervals will be watched during each period of the day.

Biological Monitoring

Current target numbers for biological monitoring are expected to adequately represent the Peconic River alewife population. Targets are for the entire season. No weekly targets have been set since alewife migration varies over the course of the season. If alewife abundance

increases, sampling may need to be proportionally increased, but time and available resources will need to be considered.

A8. Special Training/Certification

Project staff will train volunteers and interns conducting visual counts or counting fish from video recordings prior to beginning the work. Any volunteers or interns assisting with biological sampling will be trained on appropriate methods for taking size measurements, determination of sex, and scale removal and supervised by Byron Young, a retired NYSDEC biologist who has been conducting biological sampling of alewife for many years, or current NYSDEC biologists. A record of all volunteers and training dates will be kept by Elizabeth Hornstein (see Appendix D).

Scale samples and otoliths samples will be analyzed by trained biologists and technicians at the NYSDEC Marine Resources Division or NYSDEC Region 1 Freshwater Fisheries Unit. Biologists and technicians will be trained by staff from the NYSDEC Hudson River Fisheries Unit that have multiple years of experience in ageing alewife.

A9. Documents and Records

All data recorded in the field will be done using online data sheets, or waterproof paper datasheets and later transcribed into digital files. All video footage will be regularly downloaded by the interns, uploaded to a specific "Alewife Video Recordings" folder that will be accessible to PEP Staff, and saved to an external hard drive. Fish counts from the video footage will be recorded in excel spreadsheets. All electronic and paper copies of the data will be kept by PEP and shared with NYSDEC Freshwater Fisheries Unit and other relevant partners. A minimum of two copies will be made of all electronic data and video recordings. An annual report will be produced each year, summarizing the Peconic Estuary alewife monitoring efforts and results, and will be published on the PEP website.

Elizabeth Hornstein, Project Manager, will be responsible for maintaining the official, approved QAPP and disturbing the most current, approved copy to all personnel on the distribution list, as well as to any interns/volunteers participating in monitoring activities.

B. Data Generation and Acquisition

B1. Sample Process Design (Experimental Design)

Peconic River Alewife Monitoring

Current diadromous fish restoration efforts have been focused on the Peconic River over the last couple decades. To evaluate the success of these restoration efforts, alewife monitoring will largely be focused in the Peconic River, at the Grangebel Park Fishway and Woodhull Dam. The

objectives of the Peconic River Alewife survey are to:

1. Determine the presence of spawning alewives upstream of the Grangebel Park Rock Ramp;
2. Document the timing of the alewife run through visual observations on the Peconic River
3. Estimate the size of the Peconic River spawning run; and
4. Collect biological data from a sample of spawning adult alewives in the Peconic River.

Grangebel Park is located at the intersection of Peconic Ave and Heidi Behr Way in Riverhead, NY 11901. Grangebel Dam, located within the park, marks the first barrier the alewife encounter during their spawning run throughout the Peconic River. In 2010, a permanent rock ramp was built that allows fish to bypass the dam and make their way into the pool on the other side (Figure 3). Because the majority alewives migrate through the Grangebel Rock Ramp in the evening and there is a strong river flow at this site, visually observing alewife passing through this fishway is challenging. In spring 2019, a 950 Sea-Drop Analog Camera by SeaViewer was installed at the Grangebel Dam fishway to determine if video recording could successfully be used to estimate the number of alewives using the fishway. This project was highly successful, so video monitoring will continue in spring 2020 and annually thereafter, contingent upon available funding and resources. Video monitoring at the site will allow for annual estimates of the number of alewives coming up the Peconic River to spawn and enable tracking of changes in alewife abundance over time.

Installation of the video monitoring system at Grangebel Park, includes a wooden framed structure with an enclosed glass area for the camera. Two weirs on the upstream side of the wooden frame structure (Figure 4) are used to ensure all fish must pass through the wooden box and are captured on the camera. The 950 Sea-Drop Analog Camera is equipped with high resolution imaging, color or black and white imagery, and LED lighting for nighttime videography. The camera records 24 hour video footage and uses 32GB and 64GB SD cards to store the footage. A site job box holds the equipment connected to the camera, including the SD cards and a screen showing the live camera footage (Figure 4). The camera is connected to a nearby electrical source.

Figure 4 – Video monitoring set-up at the Grangebel Park fishway (left) and site job box (right)

Woodhull Dam, located on Little River, a tributary to the Peconic River. is located at 300 Center Dr S, Riverhead, NY 11901. Most of the fish that use the Grangebel fishway head up Little River until they reach Woodhull Dam. At this site there is a pool below the dam where the alewives end up spawning, since they cannot overcome the dam to continue to their desired upstream habitat.

Alewives in the pool below Woodhull Dam are easily visible and easily captured with a cast net for biological sampling. Ongoing biological monitoring of the alewife population, including size measurements, determination of sex, and scale retrieval for age estimates, along with visual abundance estimate of alewife at Woodhull Dam will continue in spring 2020. The current target is to collect length and sex information from 600 fish, and scale samples from 200 fish. Additionally, if feasible, a small subsample of alewife will be sacrificed for paired otolith and scale age analysis. In winter 2020/2021, a video monitoring system will be installed during the construction of the Woodhull Dam fishway that will record the number of alewives successfully using the fish passage. An underwater video camera will be installed at the exit of the fishway along with a site job box that will house a connected laptop. A new electrical panel will be installed at this site to power the camera. Video monitoring will begin in spring 2021 to record fish utilizing the newly constructed fishway. Video monitoring at this site will allow for an estimate of the number of alewives that travel up Little River run to spawn after bypassing the Grangebel fishway (as opposed to heading up the main stem of the Peconic River), and successfully transverse the fishway. Biological monitoring is expected to continue to occur at Woodhull Dam following the installation of the fish passage, but collection methods may need to be adjusted, since installation of the fish passage is expected to decrease the numbers of fish congregating below the dam.

Fish passages at the Upper Mills Dam and Forge Rd Dam on the main stem of the Peconic River are currently in the engineering design/permitting phase. A fish passage at the Edwards Avenue Dam has already been constructed. Visual and/or video monitoring may be conducted at these sites in the future to evaluate the success of these projects and determine how far upriver alewives travel. A standard video analysis procedure will be adopted to ensure comparability among sites.

Alewife Monitoring of other tributaries in the Peconic

Monitoring may be expanded to other tributaries within the Peconic Estuary watershed in the future, as fish passage enhancement projects are completed in other tributaries around the Estuary. Currently, projects are planned at Alewife Creek in Southampton and Lake Montauk in East Hampton. Monitoring may include any of the following: biological sampling, visual abundance estimates, and video count estimates, as described in the next section. Visual abundance counts will be used to provide first-order and relative abundance estimates, and/or to confirm the success of a fishway. Visual run counts are best for sites where the target species is the dominant species and should be conducted at fishways or narrow passageways (e.g., natural bottleneck, weir) in clear, shallow water where all fish pass through a visible point. Video monitoring may be employed to obtain more precise alewife abundance estimates. 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. In tributaries with consistent alewife spawning runs (e.g. Alewife Creek), biological sampling may be conducted to provide baseline biological information.

The Peconic Estuary Alewife Monitoring Program will be reviewed annually. Yearly reports will be produced to summarize the Peconic Estuary alewife monitoring efforts and results.

Table 1: Project Task Schedule

Task	Date Undertaken

Video Monitoring at Grangebel Park Fishway	Annually March 1-May 15, beginning in 2020
Video Monitoring at Woodhull Dam Fishway	Annually March 1-May 15, beginning in 2021
Biological Sampling of Alewife in the Peconic River system	Annually March 1- May 15, as feasible
Data Analysis	Annually, May-August
Report Synthesis	Annually, September-December
Review and adjustments to monitoring plan/QAPP as needed	Annually in January
Re-authorization of QAPP every 5 years	Beginning 2025

B2. Sampling Methods

Visual Counts:
Visual Count Surveys will follow the Alewife Visual Survey Protocol (2020) in Appendix A.

At Woodhull Dam, visual abundance estimate have been made in the pool below the Dam since 2010 and will continue to be made by retired NYSDEC biologist Byron Young in spring 2020. Fish are counted in a portion of the pool and then the count number is extrapolated to the whole pool. Counting the number of alewives in the entire pool is not possible due to the number of alewives present and size of the pool. Daily abundance estimates will be made up to three times a week, and then will be extrapolated to produce weekly abundance estimates and a total estimate for the entire spawning season. Because alewife congregate and spawn in the pool below Woodhull Dam, there is a risk that the fish may be double-counted throughout the spawning season; a correction method to account for double-counting will be determined, in conjunction with Peter Daniel of Hofstra University, who is currently conducting a tagging study on the Peconic River to evaluate alewife movements.

Visual counts at other sites/locations will be conducted by experienced biologists or trained volunteers. Visual counts will be conducted at fishways or narrow passageways in clear, shallow water where all fish pass through a visible point, or in clear, shallow water pools at the base of a dam. All volunteers conducting visual counts must attend a training workshop prior to beginning monitoring. Volunteers will inspect or watch a site for fixed durations of time (15 minutes) and count how many alewives were present. Depending on the level of effort at each site, daily or weekly results will be averaged to reflect the number of alewives counted in fifteen minutes and may then be multiplied by a factor of 96 to come up with an estimated daily total fish estimate or 672 to come up with a weekly total fish estimate. Daily and/or weekly abundance estimates will only be produced for sites where there is consistent sampling. A correction method to account for potential double-counting, due to milling, will be determined and applied based on the results of the Peconic River alewife tagging study.

Video monitoring:
Video monitoring systems will be used at certain sites to provide a more robust estimate of alewife abundance. Video monitors will only be installed at fishways or passageways (e.g., natural bottleneck, weir) where all targeted species pass in front of the camera and visibility is adequate. PEP staff, NYSDEC staff, and trained interns/volunteers will maintain the video monitor systems throughout the spawning season; this will include cleaning the cameras to keep them free of debris and downloading the recorded video at least twice per week. Trained interns will watch the recorded video footage to count the number of alewives that pass by the camera. To reduce the amount of video footage that needs to be watched, a random stratified subsampling method will be used, whereby a representative number of video segments are watched per day, and count numbers are then extrapolated to provide a daily estimate. In the 2019 pilot video monitoring at Grangebel Park, 20 random ten-minute segments were watched per day. Moving forward, because alewife migration seems to be concentrated at certain times of the day, a two-way sub-sampling design will be used, as recommended by Nelson et al. 2006. In this design the day will be divided into four equal periods (12:00am to 5:59am, 6:00am to 11:59am, 12:00pm to 5:59pm, and 6:00pm to 11:59pm), and 5 random ten-minute segments will be watched per period, for a total of 200 minutes per day. Each day the intervals to be watched will be generated randomly using Microsoft Excel. The fish recorded at each segment will be recorded in an Excel sheet and daily estimates will be generated using the formulas in Nelson 2006. The mean number of alewives per time unit of each period of day k is $\hat{y}_{kp} = \Sigma y_{kpi/nkp}$ where $\hat{y}_{kp}$ is the mean, y_{kpi} is the ith count during period p on day k and n_{kp} is the number of time units sampled per period on day k. The mean can then be multiplied by the number of time intervals in each period (36), and then the abundance counts for each period can be summed together to estimate the number of alewives passing through the fishway each day. Daily abundance estimates will then be summed across the spawning season to produce a total population estimate. Sample variance, total variance and the 95% confidence interval will also be calculated using the formulas described in Nelson 2006 (see Appendix G). A correction method to account for potential double-counting, due to milling, will be determined and applied based on the results of the Peconic River alewife tagging study.

In the future, we may explore using available software, like Salmonsoft, that records video only when fish are detected, and counting all recorded fish. This method would then be compared to the random subsampling method to evaluate consistency and determine the most robust sampling method, given available resources.

If for any reason, video is not recorded for a period of time or the video is not sufficient for accurately counting fish, the team will discuss how to correct for this in the analysis, and this information will be noted in all publications and communications of the study results.

Biological monitoring:
Ongoing biological monitoring of the alewife population, including size measurements, determination of sex, and scale retrieval for age estimates, will continue to occur at Woodhull Dam in the Peconic River system, as feasible. Biological monitoring may be expanded to other tributaries in the future. Cast nets, dip nets, or hand harvesting will be used to capture adult alewife. Fish will be held in a large bin with water, and one at a time fish will be palpated to determine sex, measured to determine length to the nearest millimeter, and, if time/resources allow, weight to the

nearest gram. From every third fish, 20-30 scales will be collected ventral of the dorsal fin using a clean pocket knife, and placed in scale envelopes, labeled with the collection date, sex and length/weight measurements, for future age analysis. After measurements are made, the fish will be released. However, a small subset of fish (up to 20/year) may be sacrificed for paired otolith and scale age analysis to identify any differences and evaluate the precision of these two methods. Scale samples will be transferred weekly to NYSDEC Division of Marine Resources (East Setuaket, NY) for future age analysis. Any sacrificed fish will immediately be transferred to NYSDEC Division of Marine Resources or Region 1 Freshwater Fisheries Unit (Stony Brook NY) for processing. Otoliths will be removed from scarified fish, cleaned and stored dry in microcentrifuge tubes labeled with collection date, fish sex and length. Biological sampling will follow the Alewife Biological Sampling Protocol (Young 2011) in Appendix B. Age analysis will follow the Alewife Ageing Protocol (Massachusetts Division of Marine Fisheries 2015) in Appendix C. Biological data will be entered into an excel spreadsheet. Mean, median, range and standard error will be calculated for size and age measurements using basic statistical functions in excel.

B3. Sample Handling and Custody

Visual alewife abundance information will be submitted through online data sheets as described in the Alewife Visual Survey Protocol (2020) in Appendix A. Biological data will be recorded on water proof data sheets and subsequently transcribed into excel or an equivalent spreadsheet program as described in the Alewife Biological Sampling Protocol (Young 2011) in Appendix B. All video recordings will be downloaded, and video count numbers will be entered in excel or an equivalent spreadsheet program. All paper and electronic records of the data will be submitted to Elizabeth Hornstein, PEP State Coordinator at the NYSDEC Marine Resources Office in East Setauket, NY and the NYSDEC Freshwater Fisheries Unit Office in Stony Brook, NY.

All scale envelope samples will be labeled with the collection date and the sex and length of the fish. Scale samples will be delivered to NYSDEC Division of Marine Resources for future age analysis, and a laboratory representative will verify the samples were received. Any fish sacrificed for otoliths will be immediately brought to NYSDEC Division of Marine Resources or Region 1 Freshwater Fisheries Unit for immediate processing, and a laboratory representative will verify the fish were received. Laboratory biologists/technicians will remove the otoliths, rinse them with water and store them dry in microcentrifuge tubes labeled with collection date, fish sex and length. Age analysis results will be stored with the PEP and the NYSDEC.

See Appendix E for Sample Handling and Custody Tracking Form.

B4. Analytical Methods

Age analysis from scale and otolith samples

Scale and otolith samples will be aged by trained biologists/technicians at NYSDEC Division of Marine Resources or NYSDEC Region 1 Freshwater Fisheries Unit and will follow the Alewife Ageing Protocol (Massachusetts Division of Marine Fisheries 2015) in Appendix C. Ageing of a small number of otoliths will be used to identify any differences between age estimates from

otoliths and scales, and compare the precision of these two ageing methods. Following processing, the scales and otoliths will be placed back into their individual envelope/container. Effort will be made to analyze scale and otolith samples in a timely manner but there is no limit on holding/processing time.

All scales and otoliths will be examined by two agers. If the two agers agree, the age (determined from the number of annuli) will be finalized and recorded. Disagreements will require analysis by a third ager. Metrics will be finalized when two of the three agers agree. If no agreement occurs, the sample (and associated fish) will be removed from aging analysis. Once ages have been agreed upon for a fish, technicians will write the value onto the scale envelope or otolith container and enter them into a database.

B5. Quality Control

Byron Young, a retired NYSDEC biologist, will be responsible for alewife biological sampling and making visual abundance estimates at Woodhull Dam. Byron has been carrying out the monitoring at Woodhull Dam since 2010. If any other personnel are involved in the monitoring at Woodhull Dam, they will be trained by Byron or current NYSDEC biologists. Volunteers conducting visual abundance monitoring at other sites will be required to attend a training workshop led by PEP staff prior to beginning monitoring. Volunteers/interns analyzing the video data will also be trained by PEP staff on how to identify alewife and counting and analysis procedures. Data will be checked for quality by Elizabeth Hornstein, PEP State Coordinator and Project Manager. Checks will be done to ensure completion of all fields on data sheets, examined for potential outliers/errors, and QA/QC will be done on all the data that was entered into online databases from hard copy data sheets by someone that did not enter the information (See checklist in Appendix F). A subset of the video segments will be watched by Elizabeth Hornstein to verify counting accuracy. Following analysis of the video data, sample variance, total population variance and the 95% confidence interval will be calculated using the formulas in Nelson 2006 (See Appendix G).

Scale and otolith samples will be submitted to NYSDEC Division of Marine Resources Diadromous Fisheries Unit or NYSDEC Region 1 Freshwater Fisheries Unit for age analysis. All scales and otoliths will be examined by two agers. If the two agers agree, the age (determined from the number of annuli) will be finalized and recorded. Disagreements will require analysis by a third ager. Metrics will be finalized when two of the three agers agree. If no agreement occurs, the sample (and associated fish) will be removed from aging analysis.

B6. Instrument/Equipment Testing, Inspection and Maintenance

All video monitoring system equipment will be tested prior to the beginning of each field season by PEP Staff to ensure it functions properly. Video cameras will be cleaned and checked at least twice per week throughout the field season by PEP staff and interns to keep them free of debris and ensure quality video data is recorded. If recorded video is not clear enough to accurately count fish, this data will not be utilized, and additional video maintenance/cleaning plans will be

implemented to try to rectify the issue.

Laboratory ageing equipment will be inspected and maintained by laboratory technicians.

B7. Instrument Equipment Calibration and Frequency

Not Applicable

B8. Inspection/Acceptance of Supplies and Consumables

All video monitoring system parts will be ordered from reputable vendors and will be inspected prior to use by PEP Staff.

B9. Non-direct Measures

Not Applicable

B10. Data Management

Data from the field will be recorded on waterproof data sheets or submitted using online data sheets. Data recorded on paper data sheets will subsequently be entered in excel or an equivalent spreadsheet program. Copies of all paper and electronic data will be provided to Elizabeth Hornstein, PEP State Coordinator and Project Manager and will be checked for QA/QC by Elizabeth. Data will also be submitted to and reviewed by the NYSDEC Freshwater Fisheries Unit.

C. Assessment and Oversight

C1. Assessments and Response Actions

The PEP Director will oversee all aspects of the project and will give the final verification of all data and reports prior to annual release. Additional oversight will be provided by the NYSDEC Freshwater Fisheries Unit and the New England Interstate Water Pollution Control Commission (NEIWPCC). NEIWPCC may implement, at their discretion, various audits or reviews of this project to assess conformance and compliance to the quality assurance project plan in accordance with NEIWPCC Quality Management Plan. NEIWPCC may issue a stop work order and require corrective action(s) if nonconformance or noncompliance to the Quality Assurance Project Plan is found.

C2. Reports to Management

Annual reports will be produced to summarize the Peconic Estuary alewife monitoring efforts and results. Elizabeth Hornstein will primarily be responsible for report generation. Draft reports will be reviewed by the PEP Director and NYSDEC Freshwater Fisheries Unit. Final reports will be

posted on the PEP website.

D. Data Validation and Usability

D1. Data Review, Verification and Validation

All data sets will be checked several times from collection through report submission. Elizabeth Hornstein, Project Manager, will perform random checks on all stages of the data collection and analysis. Data will also be reviewed by the NYSDEC Freshwater Fisheries Unit. The PEP Director will give the final verification of all data and reports prior to release.

D2. Verification and Validation Methods

To verify and validate the data, checks will be done to ensure completion of all fields on data sheets, examined for potential outliers/errors, and QA/QC will be done on all the data that was entered into online databases from hard copy data sheets by someone that did not enter the information (See Appendix F). A subset of the video recordings will also be watched by Elizabeth Hornstein to verify fish counting accuracy. Following analysis of the video data, sample variance, total population variance and the 95% confidence interval will be calculated using the formulas in Nelson 2006 (See Appendix G).

All scales and otoliths will be examined by two agers. If the two agers agree, the age (determined from the number of annuli) will be finalized and recorded. Disagreements will require analysis by a third ager. Metrics will be finalized when two of the three agers agree. If no agreement occurs, the sample (and associated fish) will be removed from aging analysis.

D3. Reconciliation with User Requirements

The data will be checked for quality assurance according to this document and then a meeting will be convened by the project group to discuss the data and its analysis and any issues that may exist. This meeting will determine if any aspects of the data should be adjusted or discarded due to documented errors or equipment malfunctions. Any changes or omissions could limit the utility of the study; therefore, any alterations will be fully disclosed in the annual reports and in any specific requests for the data.

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Appendix A. Alewife Visual Survey Protocol

Based on Protocol developed by Seatuck Environmental Association for the Long Island River Herring Volunteer Survey and methods in Nelson 2006.
February 2020

Monitoring Schedule
Monitoring will take place from **March 1 to May 15**.

Volunteers are asked to visit the monitoring site as often as possible. To create a more randomized sampling approach, volunteers are not given a time of day or specific tide in which to collect data. However, it is important that we spread our effort out over the survey sites and spawning period to get a better understanding of the dynamics of alewife runs in the individual tributaries. To facilitate this, we encourage volunteers to coordinate their sampling effort with one another and maintain a tentative survey schedule to help with this.

Safety
Dress for all weather conditions and wear bright clothing to make yourself visible to motorists if you are monitoring near a roadway. Make sure someone knows where you are headed and bring a partner if possible. If you have any concerns regarding safety, leave the site immediately.

Equipment
What to bring:

- Watch
- Pencil
- Data sheet and surface to write on, or online device to access online survey (available here)
- Survey protocol
- Polarized glasses if you have a pair
- Clicker to keep track of fish count
- Thermometer (optional)
- Digital camera (optional)

At your site:
Find a way to minimize glare and increase your ability to see into the water. Alewives will be easiest to see against a light background. Observe the area for 15 minutes looking for movement and schooling fish in the water or trying to cross the barrier.

Record the following information using online data sheet or a waterproof paper data sheet. Observations recorded on paper data sheets should later be transcribed into the online data sheet or into an excel spreadsheet.

- Tributary/Observation Site
- Date
- Monitoring Start/End Time
- Tide Stage
- Water Temp (if you have a thermometer)
- Weather Conditions
- Alewives
    - Yes/no

    - Approximate count
- Other interesting observations or notes. Any interesting observations or conditions you observe are worth noting; this is often how we learn things we didn't expect when designing the study.
- If you have a camera with you and see fish in the water or on the bank, or if you observe interesting animals or conditions, please take pictures and upload them to the online data sheet.

Data response:
Your data can be submitted online via:
https://survey123.arcgis.com/share/fa83ebfe190f417086be483166182464?
We prefer this method of submission because it allows us to track progress during the survey and supplement observation effort when necessary. If you prefer to use paper data sheets at your site, you can either enter the information into the online survey once you return from your site or send us the hard copy.

Contacts:
If you have any questions or concerns, please contact:

Elizabeth Hornstein
(631) 444-0871
elizabeth.hornstein@dec.ny.gov

Appendix B. Alewife Biological Sampling Protocol

Protocol developed by Byron Young, retired NYSDEC biologist, 2011
Last modified February 2020.

Alewives have been collected from the pool below Woodhull Dam on Little River, the main tributary to the Peconic River that drains Wildwood Lake since 2010. Small numbers of fish have also been collected intermittently for biological sampling in other tributaries (e.g. Alewife Creek).

Equipment:

- Cast Net – a four-foot diameter cast net with ¾ inch stretched mesh has been employed successfully at the Woodhull Dam. It is felt that anything larger would catch to many fish in a single toss and most likely would become entangled in the debris in the pool more easily.
  Or
  Dip Net – a small fishing net with a long handle
- Collection buckets –Three to four five-gallon buckets for holding the fish and acting as supports for the measuring board and scales. You can also use any type of container to hold the fish alive while collecting biological data, a cooler, a larger bucket or a small garbage can.
- Metric measuring board, 1/2 meter or less as the fish are generally less than 300 millimeters in length.
- Dietary scale to measure weight on a sub-sample of the fish, the fish generally weight less than 250 grams (optional)
- Thermometer (optional)
- Waterproof note book or note paper, or data sheet.
- Scale envelopes, coin envelopes for storing any scale samples collected.
- Pocket knife for collecting scales.
- Pencils.
- Boots and other foul weather gear
- Camera
- Proper DEC identification

Monitoring methods:

- Prior to collection, fill at least two buckets with water from the stream for holding the live fish (at least one bucket for fish that have not been measured and one bucket for fish that have been measured), set-up measuring/sampling equipment and data sheets.
- Record the date, time, sampling site, tide stage, and weather conditions. Record water temperature using a thermometer if possible.
- Collect adult fish using a cast net or dip net. Alewives can also be captured by hand; however, this is only effective when the fish are present in large numbers. Place live fish into a holding bucket/container. Released any stressed fish right away.
- Remove fish one at a time from the container, palpate to determine sex, and then measure total length and fork length to the nearest millimeter*, and weight to the nearest gram (optional).
- From every third fish, collect 20-30 scales ventral of the dorsal fin using a clean pocket knife. Place scale samples in the envelopes and write the sex and length of the fish on the envelope**.
- Following measurements, place fish into a holding bucket for measured fish. Release all fish back to the stream/pond after taking measurements on the whole batch, or sooner if the fish seem stressed.
- Rinse or wipe clean all equipment following sampling.

*Fork length and total length should be taken when beginning biological sampling in a new tributary to

establish length conversion tables. Once conversion tables have been established, only total length needs to be taken.
**Consideration should be made to sacrificing a small sub-sample of fish from larger Alewife spawning runs for paired otolith and scale age analysis.

Collection targets for Peconic River – Woodhull Dam

- Total length Measurement – 600 for the year. No daily target has been set.
- Scale samples from every third fish.
- Weight samples – Weight samples are very time consuming and stressful to the fish, so a smaller sub-sample is OK here. Taking weight samples typically requires additional help.

Collection targets for other tributaries
Collection targets should be determined based on monitoring feasibility and when known, the estimated alewife abundance for the tributary (at Woodhull Dam biological measurements are taken from 1-2% of the population).

Data response
Transcribe recorded field data to excel spreadsheets. Submit data and scale samples to:
Elizabeth Hornstein
Peconic Estuary Partnership State Coordinator
NYSDEC Division of Marine Resources
205 N. Belle Meade Rd. Suite 1
(631) 444-0871
elizabeth.hornstein@dec.ny.gov

Any sacrificed fish should be immediately transferred to Elizabeth Hornstein at NYSDEC Division of Marine Fisheries or Heidi O'Roirdan at NYSDEC Region 1 Freshwater Fisheries Unit (50 Circle Rd Stony Brook, NY 11790; 631 444-0281) for processing.

General notes:

- For fish in the pool below Woodhull dam there is no time of day that works better than another. If there are enough fish present, you should be able to capture some for sampling.
- If attempting to conduct biological sampling at Alewife Creek, note that the spawning run generally occurs at night. Also dip netting and hand harvest are the only methods that will work effectively in the stream.

Appendix C. Alewife Ageing Protocol

Protocol slightly adapted from the Massachusetts Division of Marine Fisheries 2015 Protocol
https://www.mass.gov/media/5411/download
**Scale cleaning and processing methods were modified based on current scale processing protocols used at the NYSDEC Division of Marine Resources, available supplies and equipment at the lab, and a scale ageing training session on March 10, 2020 led by Wes Eakin of the NYSDEC Hudson River Estuary Program, who has multiple years of experience ageing alewife scales.

Sample Collection

- Each fish is given its own sample id (river, year, and fish number).
- Length, weight, sex, species, capture date and sample id number are recorded on envelopes and data sheet.
- Fork length and total length are recorded on data sheet for every sample.
- Otoliths are extracted, wiped clean, and placed in a microcentrifuge tube with corresponding sample id number.
- Otoliths are extracted using a scalpel and forceps. Slice off the top part of the head exposing the brain cavity. Slice should be shallow starting at the back of the skull slicing forward.
- Scoop out any brain matter.
- Using forceps extract the otic membrane (otoliths should be in the otic membrane).
- Scales collected just ventral of the dorsal fin, before removal use scalpel to remove dirt and slime coat from scales.
- Take approximately 20 scales and place into an envelope with the corresponding sample id number.

Structure Processing
Otoliths

- Must be careful with otolith processing structures are very fragile.
- Water is used to clean off any dried blood.
- Dried with a paper towel then placed back into microcentrifuge tube.

Scales

- Mix up a solution of Dawn soap and water (a few drops of soap per 1000 ml of water).
- Set out 10 weigh boats and fill them with soapy water.
- Place the scales into the boats (one sample per boat). Keep track of sample numbers and corresponding boats.
- Let scales sit in Dawn solution overnight.
- The following day, go through the scales and clean them so any remaining skin/tissue is removed. Rubbing them between your fingers will help to remove any debris.
- Once you have cleaned 6-8 symmetrical, non-regenerated scales place them in a weigh boat filled with fresh water.
- Set up two microscope slides. Make sure slides are clean, if not clean with a kim wipe.
- Take scales from fresh water and dry with a paper towel.
- Place the 6-8 scales on one slide with pectinations pointing upwards.
- Once all scales are on slide, cover them with the other glass slides.
- Tape sides with scotch tap, but use just enough to hold slides together.

- Label one side of the tape with the scale id, and the other side with the date collected

Age Interpretation
Otoliths

- Set scope lens to 1.0x with reflected light.
- Immerse otoliths in mineral oil sulcus down on top of a black background.
- Annuli counted from the middle outward, counting the edge as the last annuli.
- Annuli are identified at the edge of the hyaline bands.
- The pararostrum is the clearest part of the otolith to age.

Scales

- Place slide in microfiche reader or under microscope and set scope lens to 0.5x with transmitted light. Adjust the mirror and lighting so the annuli can be viewed crossing over the baseline.
- Annuli counted from the middle outward, counting the edge as the last annuli. (Fig.1&2)
- The first dark band is the freshwater zone not the first annuli. (Fig. 1&2)
- Slight variations in scale appearance between alewife and blueback herring in terms of ageing. (Fig. 1&2)
- False annuli will not cross over the baseline and cannot be followed throughout the scale. (Fig. 3)
- Typically the second annulus is the “strongest” looking. (Fig. 4 &5)
- Annuli can become crowded together at the edge of the scale but will separate backout beneath the baseline. Should be counted as separate annuli. (Fig. 6)
- Annuli can resorb back over previous annuli but will separate back out beneath the baseline. Should be counted as separate annuli. (Fig. 6)
- Spawning marks are identified as annuli with breaks and fractures running through the band as opposed to non-spawning mark annuli that has smooth band formation. (Fig. 6)

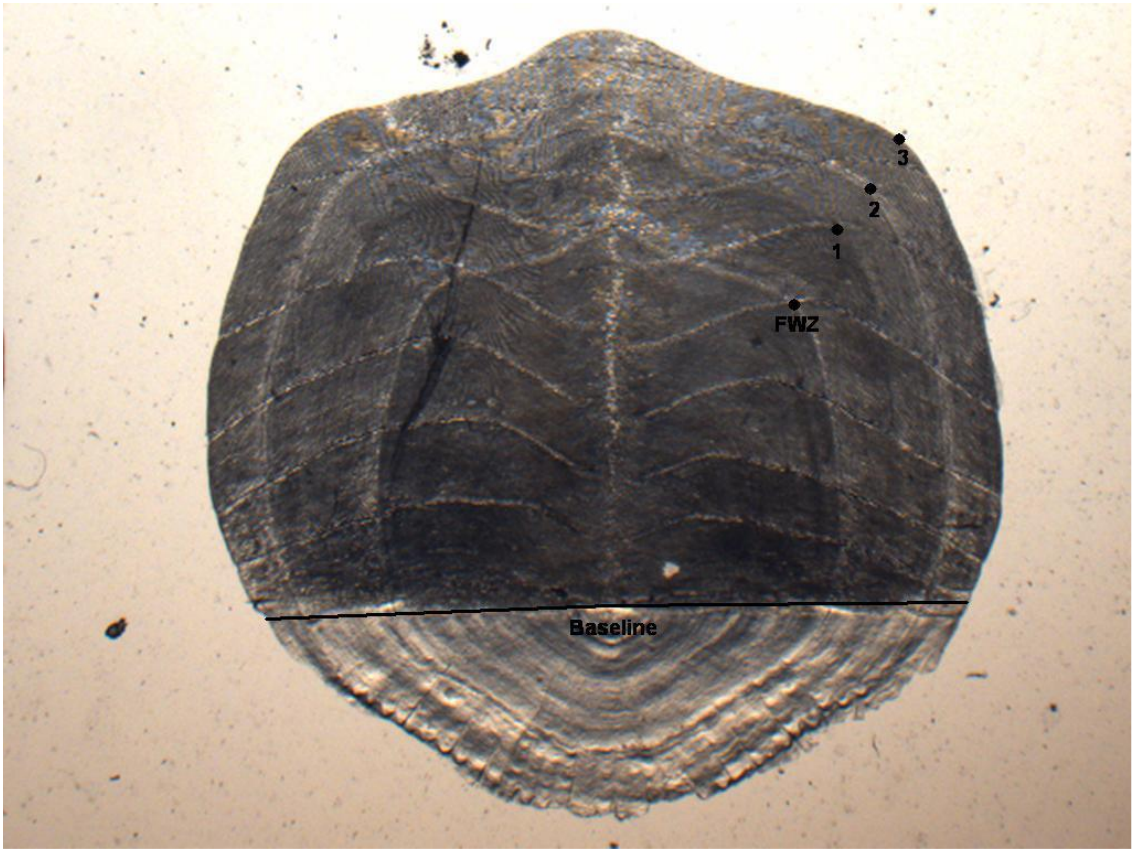

Figure 1. This 3 year old alewife has its baseline, fresh water zone (FWZ) and annuli all marked. Note the straight baseline and large FWZ typical of alewives

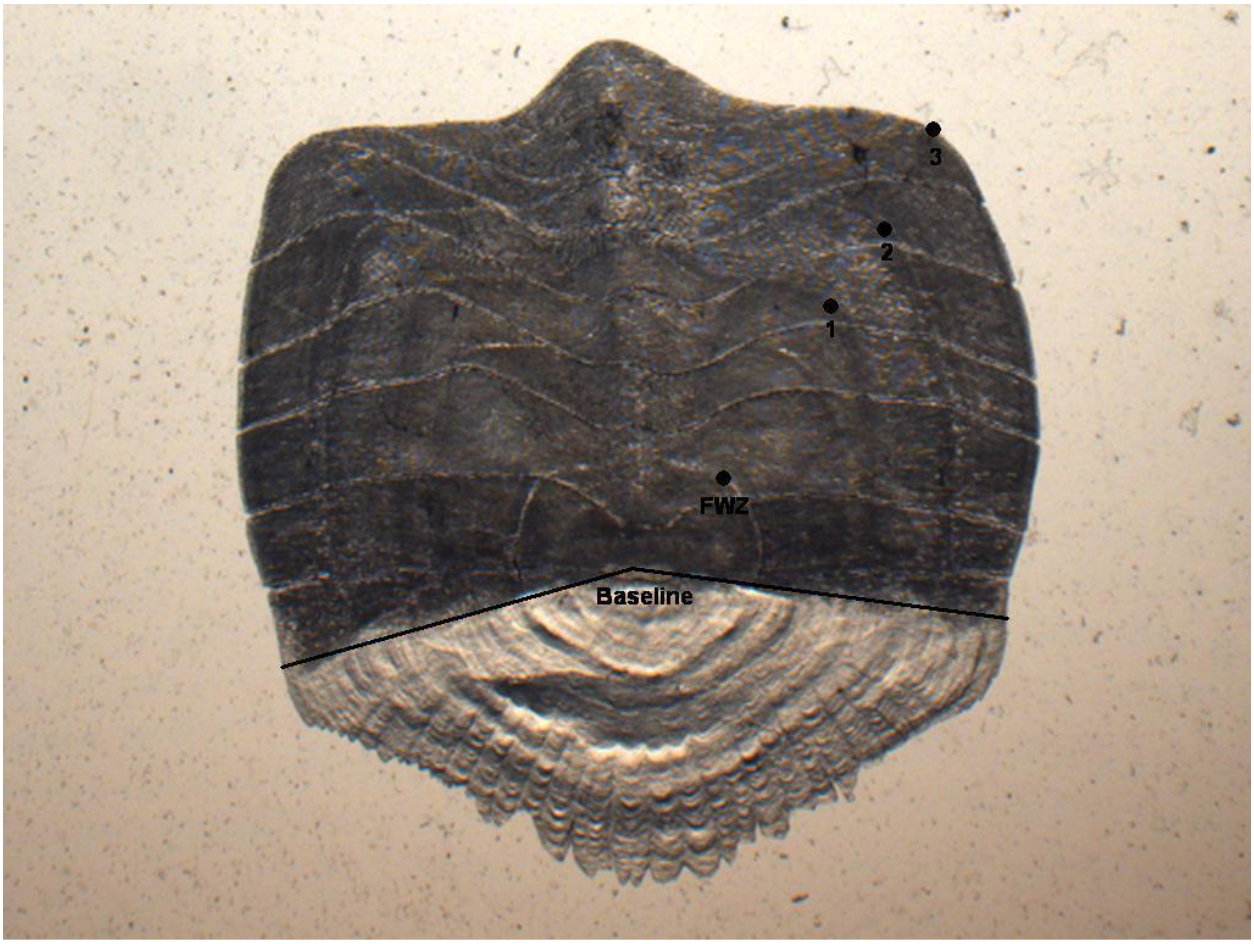

Figure 2. The baseline, fresh water zone (FWZ) and annuli are all marked on this blueback scale. Note the small FWZ and angled baseline typical of bluebacks

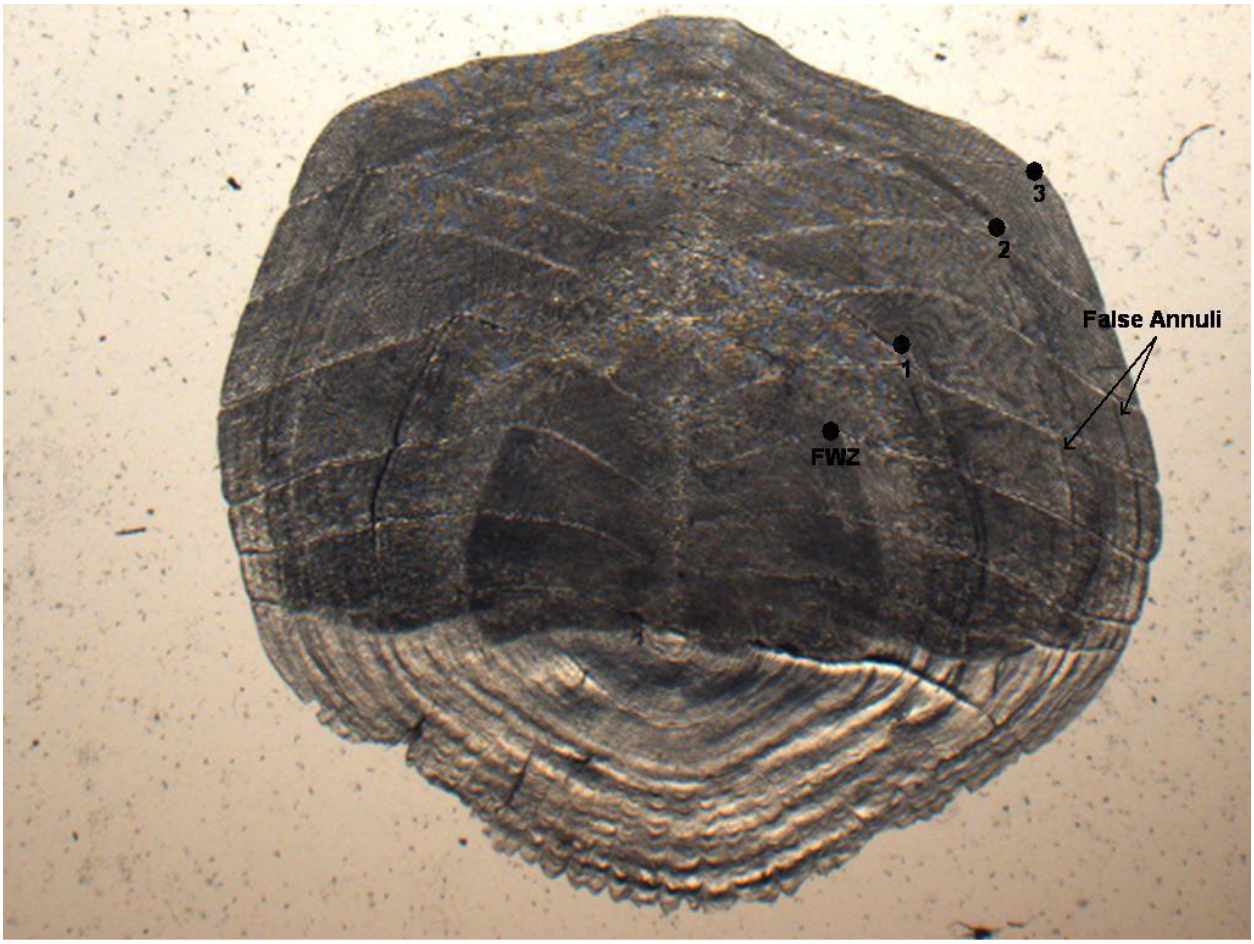

Figure 3. This three year old alewife has two false annuli, one on either side of annulus 2.

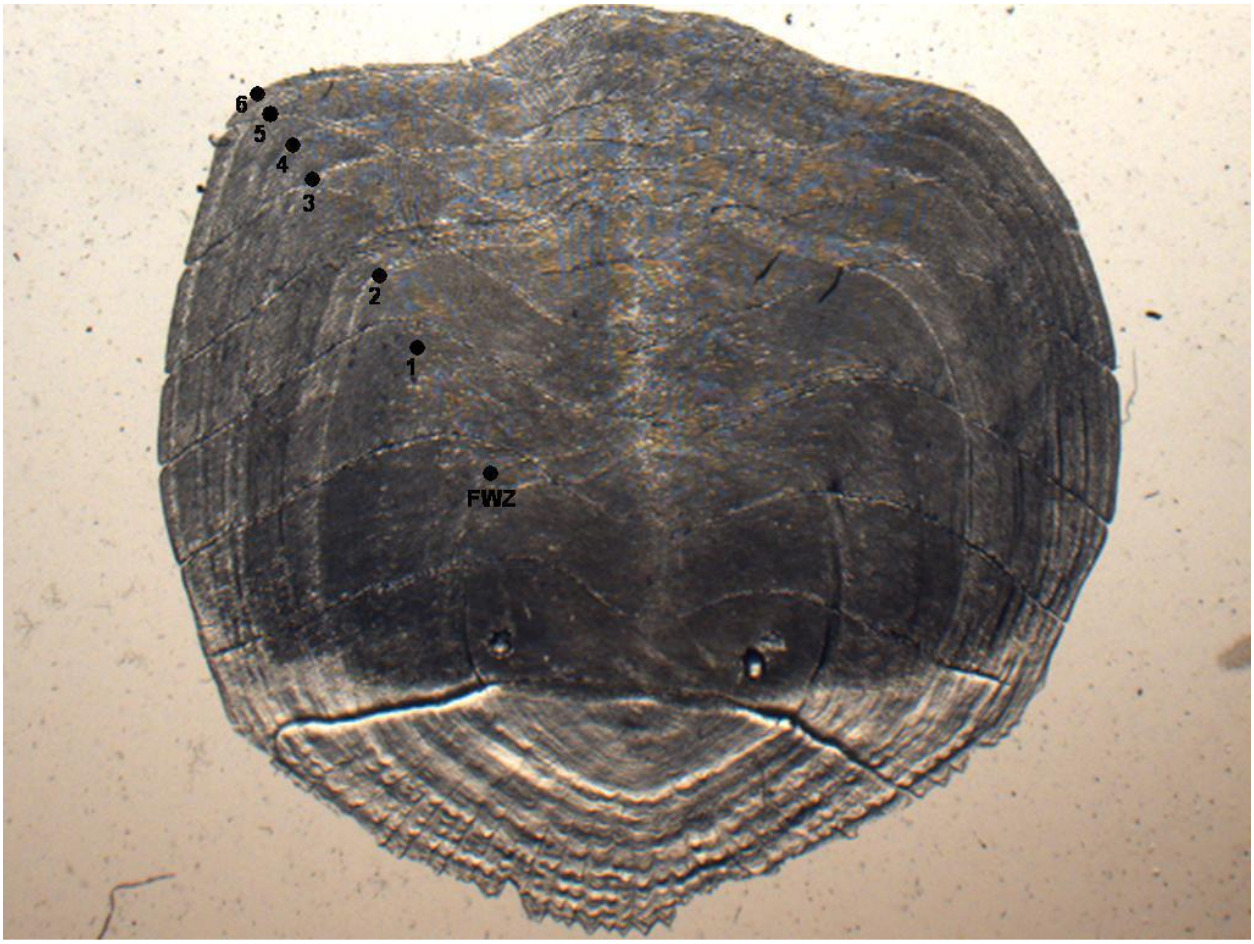

Figure 4. A six year old alewife. Note how weak the first annulus appears compared to the second.

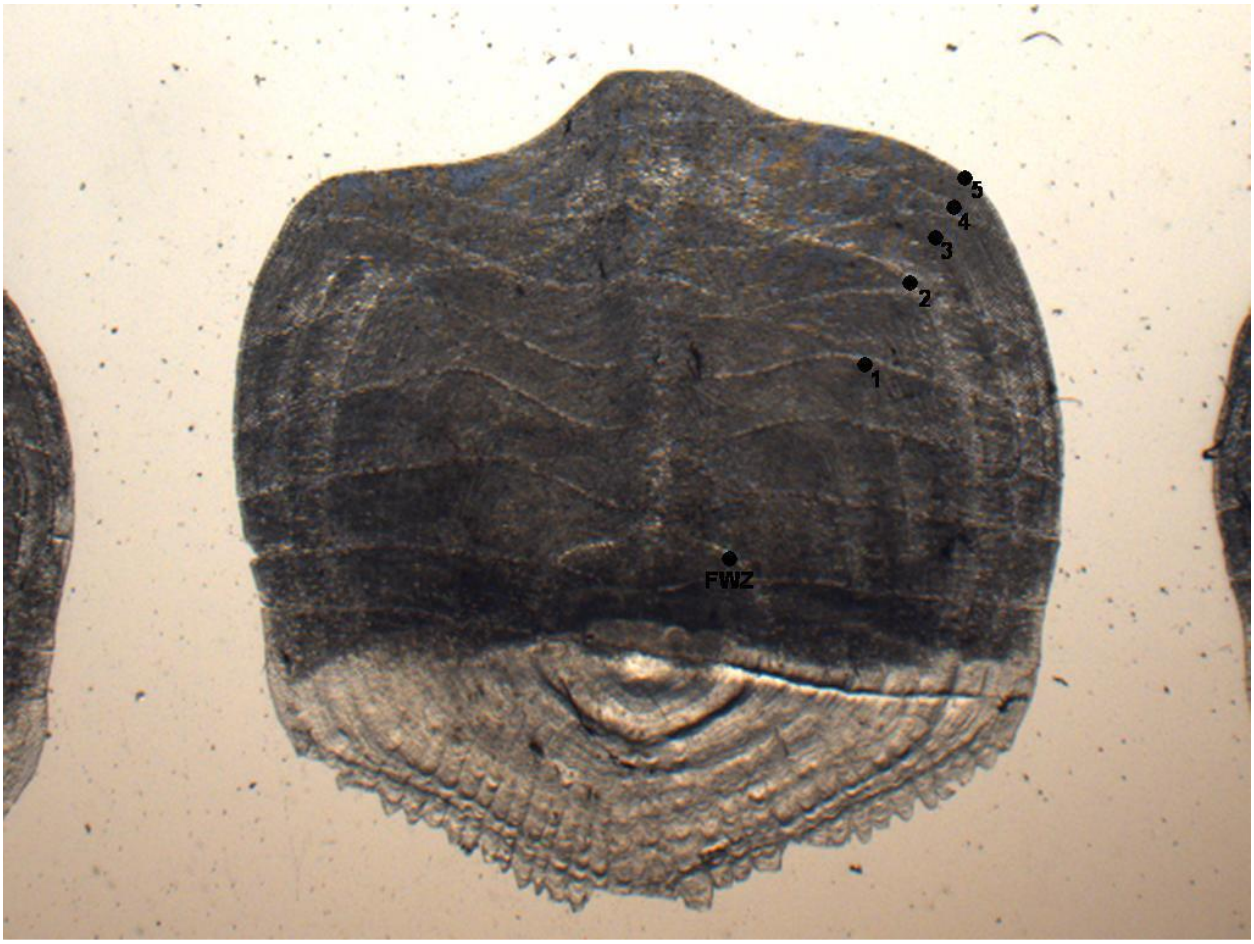

Figure 5. This five year old blueback has the typical strong second annulus.

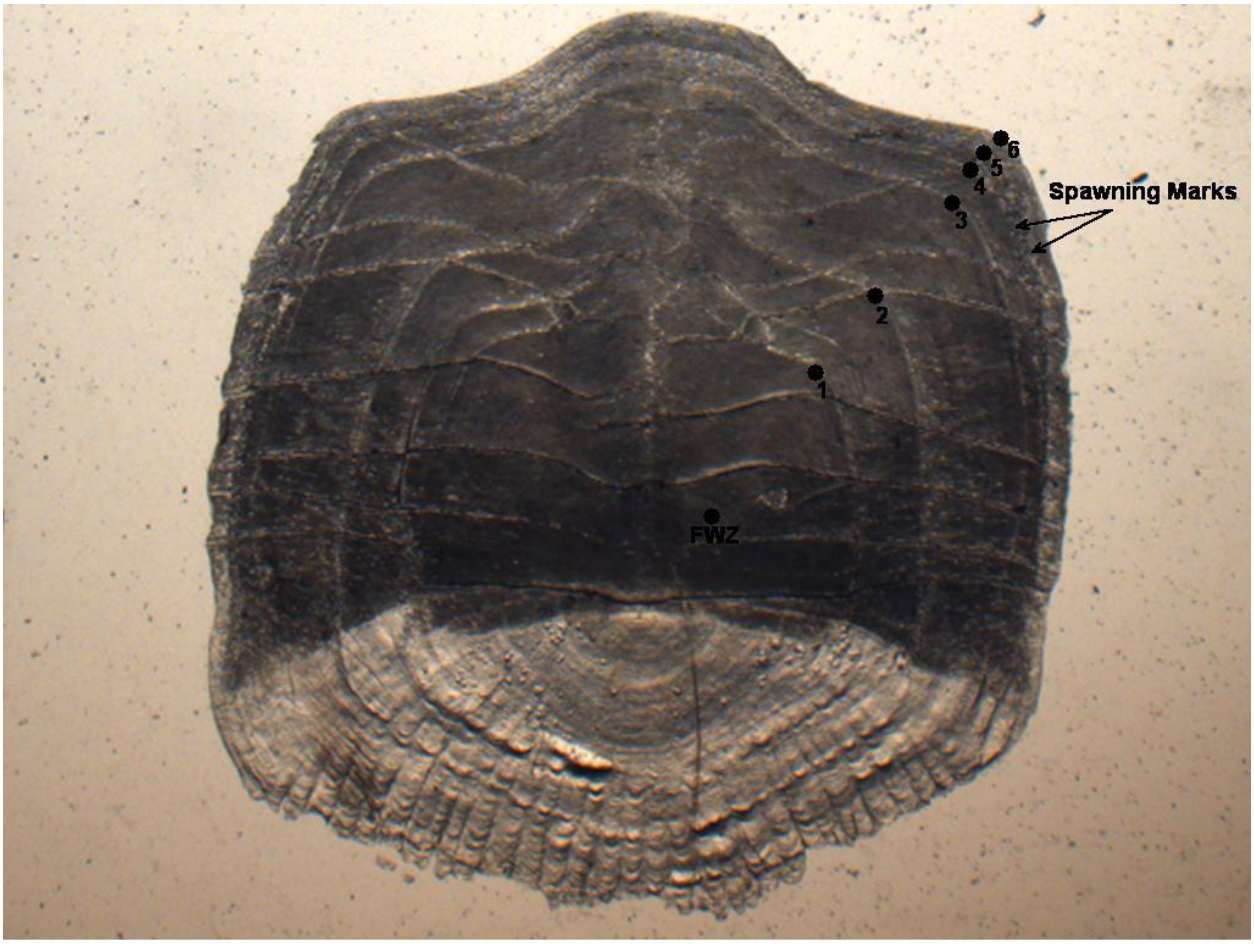

Figure 6. This six year old blueback has spawning marks at its 4th and 5th annuli.

Appendix D. Example Alewife Monitoring Volunteers List

Volunteer Name	Email	Affiliation	Monitoring Site	Monitoring Days/Times	Training Date	Notes

Appendix E. Example Sample Handling Custody Form

Sample Collector	Sample Type	Collection Date & Time	Delivered To (Staff, Location)	Delivery Date & Time	Sample Processors	Processing Date

Appendix F. QA/QC Checklist

- ☐ All data fields filled out
- ☐ Data within expected range
- ☐ Data accurately transcribed from paper to electronic database
- ☐ Data accurately processed/analyzed

Appendix G. Video Analysis Calculations

The mean number of alewives per time unit of each period on day k is:
$\hat{y}_{kp} = \sum y_{kpi/} n_{kp}$ where $\hat{y}_{kp}$ is the mean, y_{kpi} is the ith count during period p on day k and n_{kp} is the number of time units sampled during period p on day k.

Daily Abundance
$Y_k = \sum^P \hat{y}_{kp} * N_{kp}$, where N_{kp} is the total number of time units during period p and P is the number of periods during day k

Total Population Abundance
$Y = \sum Y_k$

Sample Variance for each period on day k
$s_{kp} = \sum (y_{kpi} - \hat{y}_{kp})^2 / n_{kp-1}$

Population Variance
$Var(Y) = \sum^L \sum^P N_{kp} * (N_{kp} - n_{kp}) * (s_{kp}/n_{kp})$, where L is the number of days of the run.

Confidence Intervals
$Y \pm t_{\alpha/2} * \sqrt{Var(Y)}$, where t is the two-tailed student-t critical value for α (the allowable probability of error) which provides 100(1- α)% confidence intervals given the degrees of freedom (see Sokal and Rohlf, 1981).
Degrees of freedom (*df)* = $L * \sum^P (n_{kp} - 1)$