Title: Early detection and recovery of river herring spawning habitat use in response to a mainstem dam removal

Time period: 2015–2021

Location: Patapsco River, Maryland

Purpose: To assess the response of anadromous river herring, alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*), to the 2018 removal of Bloede Dam by monitoring environmental DNA (eDNA), eggs, tagged fish (PIT tags), and adult fish (electrofishing samples) at locations upstream and downstream of the dam site during their spawning migrations.

Access: These data are not sensitive or classified.

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Cross reference: These data are used in an analysis in a published manuscript:

Huang CS, Legett HD, Plough LV, Aguilar R, Fitzgerald C, Gregory B, Heggie K, Lee B, Richie KD, Harbold W, Ogburn MB. Early detection and recovery of river herring spawning habitat use in response to a mainstem dam removal.

File names: Data:

eDNA\_data.csv

egg\_data.csv

electrofishing\_data.csv

PIT\_data.csv

Status: Ongoing

Methodology: The response of anadromous river herring, alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*), to the 2018 removal of Bloede Dam was assessed by monitoring environmental DNA (eDNA) and eggs from 2015 to 2021 at locations upstream and downstream of the dam site during their spawning migrations. The presence of adult fish was additionally assessed by collecting electrofishing samples and tracked the movements of individual adult fish within the river using passive integrated transponder (PIT) tags.

Completeness: These data are ongoing

***eDNA\_data.csv***

Description:This dataset contains river herring environmental (eDNA) data collected in the Patapsco River.

File type: Comma-separated values file

Processing steps: Sampling sites were categorized into three groups according to their geographic location relative to the Bloede Dam site including “Downstream” of Bloede Dam, “Restored” sites between Bloede Dam and Daniels Dam, and “Above Daniels” sites upstream of Daniels Dam. Water samples (~800 ml) were collected in autoclaved 1 L Nalgene bottles and samples were frozen in a non-defrosting freezer until further analysis. A total of 490 eDNA samples, including 39 control samples, were collected across 16 sample sites between 2015 and 2021. One control sample was collected for each sampling event (n = 39). Of these samples, 189 were collected from Downstream sites, 117 from Restored sites, and 97 from Above Daniels sites. Duplicate samples were also collected at all sites in 2019 (n = 109 out of 140 non-control samples), 2020 (n = 52 out of 105), and 2021 (n = 54 out of 102). One control sample was collected for each sampling event (n = 39) to show that samples were not contaminated during the collection, transport, or storage processes. Samples were frozen in a non-defrosting freezer until further analysis.

A river herring-specific quantitative PCR (qPCR) molecular beacon assay was used to identify river herring DNA sequences following established procedures. Briefly, water samples were thawed and filtered using 47 mm diameter Whatman cellulose nitrate filters with 1.0 μm pore size. DNA was extracted with the Omega Biotek EZNA Water kit following manufacturer’s instructions or with a CTAB Chloroform-Isoamyl extraction procedure. qPCR was conducted on sample extracts in triplicate, and samples with at least two out of three triplicates with cycle quantification (Cq) values below 39 were considered positive eDNA detections (i.e., river herring presence) (n = 402 out of 451 non-control samples). For samples with positive river herring detection, species-level identification of alewife and blueback herring was determined via Sanger sequencing. The relative ratio of alewife to blueback herring DNA in each sample was estimated based on the relative peak height ratios at a species-diagnostic SNP produced by QSVAnalyser and was used to calculate the number of eDNA copies per liter for each species. Copy numbers from qPCR amplification were then adjusted for each sample based on the filtered water volume, calculated as the number of mtDNA copies per liter of water sampled. Duplicate samples were collected from the sites from 2019 to 2021, so copy numbers were averaged across all replicates collected at the same site and time prior to analysis.

Source inputs: River herring-specific qPCR molecular beacon assay.

Entity and attributes:

Column heading: Site

Label: Site

Description: Specific location where samples were collected

Data type: Character

Measurement unit: None

Comments:

Column heading: Latitude

Label: Latitude

Description: Latitude of sampling site

Data type: Numeric

Measurement unit: Decimal degrees (DD)

Comments:

Column heading: Longitude

Label: Longitude

Description: Longitude of sampling site

Data type: Numeric

Measurement unit: Decimal degrees (DD)

Comments:

Column heading: Date

Label: Date

Description: Date of collection

Data type: Date

Measurement unit: None

Comments: Format: Month/Day/Year

Column heading: CqA

Label: CqA

Description: Cycle quantification (Cq) value of first qPCR run

Data type: Numeric

Measurement unit: qPCR cycle number

Comments: Cq values below 39 were considered positive eDNA detections (i.e., river herring presence)

Column heading: CqB

Label: CqB

Description: Cycle quantification (Cq) value of second qPCR run

Data type: Numeric

Measurement unit: qPCR cycle number

Comments: Cq values below 39 were considered positive eDNA detections (i.e., river herring presence)

Column heading: CqC

Label: CqC

Description: Cycle quantification (Cq) value of third qPCR run

Data type: Numeric

Measurement unit: qPCR cycle number

Comments: Cq values below 39 were considered positive eDNA detections (i.e., river herring presence)

Column heading: CnB

Label: CnB

Description: Copies detected in second qPCR run

Data type: Numeric

Measurement unit: Copy number from qPCR amplification

Comments:

Column heading: CnC

Label: CnC

Description: Copies detected in third qPCR run

Data type: Numeric

Measurement unit: Copy number from qPCR amplification

Comments:

Column heading: Mean\_Copies

Label: Mean Copies

Description: Mean raw copy number from three qPCR runs

Data type: Numeric

Measurement unit: Copy number from qPCR amplification

Comments:

Column heading: Detection

Label: Detection

Description: Presence or absence of river herring in sample

Data type: Numeric

Measurement unit: 0-1

Comments: 1 = present, 0 = absent

Column heading: Copies

Label: Copies

Description: Adjusted mean eDNA concentration (in copies per L)

Data type: Numeric

Measurement unit: Copies per L from qPCR amplification

Comments:

Column heading: AW\_Ratio

Label: Alewife Ratio

Description: Ratio of eDNA concentration identified as alewife

Data type: Numeric

Measurement unit: Proportion

Comments: 0-1.0

Column heading: BB\_Ratio

Label: Blueback Herring Ratio

Description: Ratio of eDNA concentration identified as blueback herring

Data type: Numeric

Measurement unit: Proportion

Comments: 0-1.0

Column heading: Year

Label: Year

Description: Year in which counts were collected

Data type: Character

Measurement unit: None

Comments:

Column heading: Removal

Label: Dam Removal

Description: Sample collection timing relative to dam removal (pre = before 2018, post = after 2018)

Data type: Character

Measurement unit: None

Comments: pre, post

Column heading: Group

Label: Group

Description: Habitat site grouping relative to Bloede Dam (Downstream, Restored, Above Daniels) for analysis

Data type: Character

Measurement unit: None

Comments: Downstream, Restored, Above Daniels

***egg\_data.csv***

Description:This dataset contains river herring egg data collected in the Patapsco River.

File type: Comma-separated values file

Processing steps: Ichthyoplankton sampling was conducted to assess spawning activity in the Patapsco River. Surveys of river herring eggs were conducted simultaneously with the collection of eDNA water samples at the “Downstream”, “Restored”, and “Above Daniels” sites following established protocols and standard methods used by Maryland DNR. A stationary 46 cm x 30 cm plankton drift net with 500 μm mesh and a 200 mL cod end was deployed for 5 minutes per sample. A total 284 samples were collected over the course of this study. Water velocity measurements from a flowmeter (JDC Electronics Flowatch) were used to estimate sample volume at each location. Eggs and larvae were retrieved, counted, and identified under a dissecting microscope. It is not possible to visually distinguish between alewife and blueback herring eggs, or between river herring and hickory shad (*Alosa mediocris*), due to morphological similarities at the early developmental stages.

Prior to statistical analysis, a qualitative lower threshold was established for the egg count data to account for potential sampling error. Observations with two or fewer eggs at any site were set as zero for “non-detection” (n = 34) and thus excluded from the average. The lower detection threshold would account for potential sampling cross-contamination, where residual eggs may not be thoroughly cleaned or removed from the net between new sampling events at different sites. Biological significance also informed the threshold, as even a single spawning female river herring can release hundreds of thousands of eggs into the water column.

Egg abundance was converted to catch per unit effort (CPUE) across the dataset, standardized as number of eggs 100 kL-1 of water. Calculating the volume of water passing through the collection net accounted for measured flow (cm s-1) at each site/sample, net area (cm2), and collection time (s). Normalized CPUE was rounded to the nearest egg to obtain an integer count value for subsequent models. Mean egg abundance was then compared among the sampling sites.

Source inputs: 46 cm x 30 cm plankton drift net with 500 μm mesh, flowmeter (JDC Electronics Flowatch)

Entity and attributes:

Column heading: Site

Label: Site

Description: Specific location where samples were collected

Data type: Character

Measurement unit: None

Comments:

Column heading: Latitude

Label: Latitude

Description: Latitude of sampling site

Data type: Numeric

Measurement unit: Decimal degrees (DD)

Comments:

Column heading: Longitude

Label: Longitude

Description: Longitude of sampling site

Data type: Numeric

Measurement unit: Decimal degrees (DD)

Comments:

Column heading: Date

Label: Date

Description: Date of collection

Data type: Date

Measurement unit: None

Comments: Format: Month/Day/Year

Column heading: Herring\_Eggs

Label: Herring Eggs

Description: Number of river herring eggs collected in sample

Data type: Numeric

Measurement unit: Count

Comments:

Column heading: Year

Label: Year

Description: Year in which counts were collected

Data type: Number

Measurement unit: None

Comments:

Column heading: Month

Label: Month

Description: Month in which counts were collected

Data type: Number

Measurement unit: None

Comments:

Column heading: Day

Label: Day

Description: Day of the month on which counts were collected

Data type: Number

Measurement unit: None

Comments:

Column heading: Group

Label: Group

Description: Habitat site grouping relative to Bloede Dam (Downstream, Restored, Above Daniels) for analysis

Data type: Character

Measurement unit: None

Comments: Downstream, Restored, Above Daniels

Column heading: Removal

Label: Dam Removal

Description: Sample collection timing relative to dam removal (pre = before 2018, post = after 2018)

Data type: Character

Measurement unit: None

Comments: pre, post

Column heading: Herring\_Eggs\_Threshold

Label: Herring Eggs Threshold

Description: Number of river herring eggs in sample adjusted for detection threshold (if Herring\_Eggs < 3, set to zero as non-detection)

Data type: Numeric

Measurement unit: Count

Comments:

Column heading: PA

Label: Presence-absence

Description: Presence or absence of river herring eggs in sample

Data type: Number

Measurement unit: None

Comments: 1 = present, 0 = absent

Column heading: Flow

Label: Flow

Description: Measured stream flow (in cm per second)

Data type: Numeric

Measurement unit: Centimeters per second (cm/s)

Comments:

Column heading: Sample\_Time

Label: Sample Time

Description: Amount of time stationary net was deployed for sample collection (in seconds)

Data type: Numeric

Measurement unit: Seconds

Comments:

Column heading: Volume

Label: Volume

Description: Volume of water sampled for eggs calculated by accounting for measured flow, net area, and collection time.

Data type: Numeric

Measurement unit: Kiloliters (kL)

Comments:

Column heading: EggCPUE

Label: Egg CPUE

Description: Normalized egg count per unit effort, by dividing Herring\_Eggs\_Threshold by Volume.

Data type: Numeric

Measurement unit: Eggs per kL

Comments:

Column heading: adj\_EggCPUE

Label: Adjusted Egg CPUE

Description: Normalized egg CPUE, rounded to the nearest egg (number of eggs per 100 kL of water)

Data type: Numeric

Measurement unit: Eggs per 100 kL

Comments:

Column heading: log\_adj\_EggCPUE

Label: Log Adjusted Egg CPUE

Description: Log transformed normalized egg CPUE

Data type: Numeric

Measurement unit: Log(Eggs/100 kL)

Comments:

***electrofishing\_data.csv***

Description:This dataset contains river herring electrofishing data collected in the Patapsco River.

File type: Comma-separated values file

Processing steps: Adult river herring were collected during boat electrofishing surveys at six sites on the mainstem of the Patapsco River. Three sites were located downstream of Bloede Dam (“Downstream-electrofishing”) and three sites were located upstream (“Restored-electrofishing”). Two of the Downstream-electrofishing sites (#591 and #592) were sampled for the full duration of this study (2015–2021). The remaining Downstream-electrofishing site (#593), located just below Bloede Dam in the dam’s tailrace, was not sampled after 2018 because the site converted from a pool to rapids following the dam removal and was no longer safely boatable. Boat electrofishing was not conducted above Bloede Dam (#595, #596, and # 597) between 2015 and 2018, because prior monitoring conducted from 2011 to 2014 in the dam pool and at the fish ladder exit indicated no river herring passage. Surveys were not collected at these Restored-electrofishing sites in 2019 due to mechanical issues with the electrofishing boat. Field activities in 2020 were severely impacted by COVID-19 restrictions, limiting the number of sampling events at both Downstream- and Restored-electrofishing sites. All electrofishing sites (barring # 593) were fully sampled in 2021.

Electrofishing surveys were conducted weekly at each site during the river herring spawning season (March through May), with a target of ten sampling visits per site per year. Due to COVID-19 restrictions, we were only able to sample the Downstream-electrofishing sites twice (two events in March) and the Restored-electrofishing sites five times (two events in March and three events in May) in 2020. Electrofishing at all sites was performed from a small boat while moving downstream, with total electrofishing time, fish species present, and abundance of river herring recorded for each site. Using the recorded electrofishing time and the numbers of river herring caught, relative abundance (fish collected per hour of electrofishing) was estimated for each species. Collected river herring were identified to species and total length and sex (determined based on the presence of milt or eggs, when possible) were recorded for each individual.

Source inputs: Boat electrofishing

Entity and attributes:

Column heading: Site

Label: Site

Description: Specific location where samples were collected

Data type: Character

Measurement unit: None

Comments:

Column heading: Latitude

Label: Latitude

Description: Latitude of sampling site

Data type: Numeric

Measurement unit: Decimal degrees (DD)

Comments:

Column heading: Longitude

Label: Longitude

Description: Longitude of sampling site

Data type: Numeric

Measurement unit: Decimal degrees (DD)

Comments:

Column heading: Group

Label: Group

Description: Habitat site grouping relative to Bloede Dam (Downstream, Restored, Above Daniels) for analysis

Data type: Character

Measurement unit: None

Comments: Downstream, Restored, Above Daniels

Column heading: Date

Label: Date

Description: Date of collection

Data type: Date

Measurement unit: None

Comments: Format: Month/Day/Year

Column heading: Year

Label: Year

Description: Year in which counts were collected

Data type: Number

Measurement unit: None

Comments:

Column heading: Shocker\_Time

Label: Shocker Time

Description: Duration of electrofishing in seconds

Data type: Number

Measurement unit: Seconds

Comments:

Column heading: Blueback\_Herring\_Count

Label: Blueback Herring Count

Description: Number of blueback herring collected in sample

Data type: Numeric

Measurement unit: Count

Comments:

Column heading: Alewife\_Count

Label: Alewife Count

Description: Number of alewife collected in sample

Data type: Numeric

Measurement unit: Count

Comments:

***PIT\_data.csv***

Description:This dataset contains river herring PIT tag data collected in the Patapsco River.

File type: Comma-separated values file

Processing steps: Habitat use and spawning migration movement by individual adult fish was assessed using passive integrated transponder (PIT) telemetry. These PIT tags are passive radio tags that allow the tracking of individual adult fish movement during their migration. River herring were captured via boat electrofishing from within the study system and each fish was identified to species, measured (total and fork length) and sexed (determined based on the presence of milt or eggs, when possible). All fish were surgically implanted with a 23 mm × 3.65 mm HDX+ PIT tag (Oregon RFID, Portland, Oregon, USA) following established intraperitoneal tagging methods. In short, a small incision was made just posterior to the pelvic fin, roughly three scale rows forward of the ventral midline. A PIT tag was then immediately inserted manually and the fish placed into an aerated live well. Once tagged fish returned to normal swimming behavior they were released back in the river. The scalpel width (#15 blade, 3.75 mm) was slightly larger than the tag width (3.65 mm) and closed neatly after tag implantation; thus, negating the use of sutures. Surgical handing times were short, generally less than 30 s per fish.

Tagged fish were tracked from 2016 to 2021 using multiple PIT tag antenna/reader systems (Oregon RFID, Portland, Oregon, USA). The configuration of all antennas (comprising 4-gauge fine strand copper wire) was a pass-over loop that stretched along bottom of the entire stream width (~ 10 m). The antenna shape and integrity were maintained by 3/16 in chain attached to the antenna wire and 69.5 cm sections of 1.25 in schedule 40 PVC pipe filled with cement spaced at roughly 1.5 m intervals attached to both sides of the chain in the center of the loop. We deployed antennas at three sites: “Downstream-antenna #1”, “Downstream-antenna #2”, and “Restored-antenna”. For three years pre-removal (2016–2018), only the two antennas located downstream of Bloede Dam (Downstream-antenna #1 and #2) were deployed. In 2019 and 2021, all three antennas were deployed with the Restored-antenna located upstream of the former Bloede Dam location. River herring were not tagged or tracked in 2020 due to COVID-19 restrictions on field activities. PIT tag detections were automatically logged with a timestamp by tag readers. For analysis, detections for each unique tag at any given antenna were aggregated by date.

Source inputs: PIT tags

Entity and attributes:

Column heading: TagID

Label: Tag ID

Description: Identification code for the individual PIT tag

Data type: Numeric

Measurement unit: None

Comments:

Column heading: Date

Label: Date

Description: Date of collection

Data type: Date

Measurement unit: None

Comments: Format: Month/Day/Year

Label: Site

Description: Specific location where samples were collected

Data type: Character

Measurement unit: None

Comments:

Column heading: Latitude

Label: Latitude

Description: Latitude of sampling site

Data type: Numeric

Measurement unit: Decimal degrees (DD)

Comments:

Column heading: Longitude

Label: Longitude

Description: Longitude of sampling site

Data type: Numeric

Measurement unit: Decimal degrees (DD)

Comments:

Column heading: Pings

Label: Pings

Description: Number of ping signals antenna received from tag on that day

Data type: Number

Measurement unit: Count

Comments:

Column heading: Year

Label: Year

Description: Year in which counts were collected

Data type: Number

Measurement unit: None

Comments:

Column heading: Month

Label: Month

Description: Month in which counts were collected

Data type: Number

Measurement unit: None

Comments:

Column heading: Day

Label: Day

Description: Day of the month on which counts were collected

Data type: Number

Measurement unit: None

Comments:

Column heading: Species

Label: Species

Description: Alewife or blueback herring

Data type: Character

Measurement unit: None

Comments: alewife = AW, blueback herring = BB