CONNECTICUT RIVER BASIN ANADROMOUS FISH RESTORATION: Coordination and Technical Assistance F-100-R-36

Annual Progress Report
October 1, 2018 - September 30, 2019

U.S. Fish and Wildlife Service
Connecticut River Fish and Wildlife Conservation Office
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Executive Summary

Federal Aid Project # F-100-R-36

States: Connecticut, Massachusetts, New Hampshire and Vermont

Project Title: Connecticut River Basin Anadromous Fish Restoration: Coordination and Technical Assistance

Period Covered: October 1, 2018 - September 30, 2019

This annual report provides an opportunity to organize and document, to varying degrees, all work activities conducted by the Connecticut River Fish and Wildlife Conservation Office (CTRFWCO), formerly the Connecticut River Coordinator's Office, which includes work outside of the Connecticut River basin and activities not funded by this grant.

Objectives:

- Coordinate the Connecticut River Anadromous Fish Restoration Program as a unified effort of State and Federal fishery agencies
- Provide technical assistance to the fishery agencies and other program cooperators
- Represent the Service on Commissions, Technical Committees, and work cooperatively with State agencies and other partners
- Identify fishery program priorities, design and implement projects to address issues and opportunities, and develop plans
- Administer grant programs to address fish habitat, passage, management, and research projects

Accomplishments:

Program Coordination

- Organized two Connecticut River Atlantic Salmon Commission (CRASC) and two CRASC Technical Committee meetings
- Organized the CRASC Technical Committee Research and Management Forum held in March at the USFWS Northeast Regional Office (14 Platform and 4 Poster presentations)
- Provided annual upstream and downstream fishway operations letters (for CRASC) to hydropower owner/operators and the Federal Energy Regulatory Commission (FERC)
- Coordinated river herring population assessment and restoration activities in the Connecticut River basin
- Coordinated calls on Shortnose Sturgeon passage items at Holyoke and a February sturgeon meeting at Conte Lab on passage, monitoring, evaluation and research.
- Coordinated CRASC Technical Committee (Shad Subcommittee) work (modeling by

academic partner), meetings, and writing for the 2017 CRASC American Shad Management Plan, Addendum for American Shad Fish Passage Performance Criteria.

- Developed and gave a presentation on the CRASC Technical Committee's Draft Addendum to the CRASC Connecticut River American Shad Management Plan (2017) – Fish Passage Performance at the August 8, 2019 CRASC Meeting.
    - Under direction of CRASC a 30-day public comment period was granted at the meeting and by email notification to the CRASC email distribution list and posting to the CTR FWCO web site (https://www.fws.gov/r5crc/) and (https://www.fws.gov/r5crc/pdf/CTR%20Shad%20Plan%20Addendum%208_9_19.pdf) with direction to send comments to Ken Sprankle.
    - An additional 45-day comments period was granted on September 12, 2019. An email announcement was sent out again and the web site updated. The new announcement included provided access to the reference "R" program code, CT River shad passage model outputs, and the power point presentation.

Technical Assistance

- Completed downloading and servicing of water temperature loggers at main stem river locations
- Completed juvenile American Shad fall weekly sampling that was ongoing in October 2018 through November 1, 2018. Seasonal staff completed otolith aging work on over 400 juvenile American Shad for daily growth age assignments. Field data were entered and analyzed with partnering MA Division of Fisheries and Wildlife (MADFW) to explore a number of comparison over space and time.
- Completed with MADFW the report "**Juvenile American Shad Assessment in the Connecticut River from Holyoke Dam to Bellows Falls Dam, 2017-2018**" in winter and uploaded to station web site (https://www.fws.gov/r5crc/pdf/Juvenile_Shad_Assessment_5_30_19.pdf)
- Continued in role as Chair of the ASMFC Shad and River Technical Committee over the course of the year (position extends through fall of 2020). Worked with ASMFC staff and Vice Chair to plan meetings/calls with the Technical Committee, subcommittee work groups, and individual members over the year
- Participated in ASMFC American Shad Stock Assessment Methods Workshop (week of November 2018) in Providence RI, served as member of the American Shad Stock Assessment Subcommittee and several subcommittees.
- Presented ASMFC Shad and River Herring Technical Committee work item updates and fishery management plan reviews to the Commission at their February Meeting (Arlington, VA).
- Participated in ongoing official hydropower federal relicensing meetings and interagency/stakeholder group as well as unofficial power company related study work. Confidential settlement negotiations with FirstLight were suspended in the late fall 2018, but meetings to discuss their study plans and study results continued during the report period.

Juvenile American Shad otolith, polished, tiled image, for aging.

- Participated in study planning for Great River Hydro American Eel studies (for 2019) with agency and company staff.
- Completed the Annual Sport Fish Restoration Grant Report for FY18, in January 2018 (following one month of being furloughed).
- Organize a one-day meeting among state and federal agency members to review and discuss (presentations) on recent sturgeon passage, monitoring, evaluation and research plans. Compiled data sets and developed materials with Don Pugh to review Holyoke sturgeon passage data over time (demographics, environmental factors etc.)
- Entered, summarized and analyzed (ongoing) data from the USFWS adult river herring assessment program data (2018 and 2019 season and the full time series)
- Completed a variety of analyses to develop a platform presentation "**Adult river herring population assessments in the lower Connecticut River basin (2013-2018)**" given at the CRASC Research and Management Forum on March 19, 2019, USFWS Northeast Regional Office.
- Conducted river herring population assessment surveys on 27 dates from April 2, through June 10, 2019, at five standard sample locations in Connecticut and Massachusetts
- Processed in the field a total of 3,456 Blueback Herring (BBH) and 243 Alewife (ALW) for a suite of biological data, during spring 2019 population surveys
- Processed in the laboratory a total of ,1,473 BBH and 217 ALW, subsampled from field (e.g., otolith extractions and scales)
- Cleaned and slide mounted scale samples from all 2019 lab processed river herring (N = 1,716).
- Obtained 60 American Shad from Holyoke Fish Lift, extracted tissues for fish health testing (USFWS Lamar Fish Health Unit), no pathogens detected.
- All field and lab data sheets entered into Program Assessment database, summary and descriptive statistics were developed.
- Completed otolith age determinations and scale reading for spawning history assignments from 2018 season sampled river herring in winter 2019
- Completed independent paired reading of scale for spawning history assignments with consensus determination of all 2019 river herring (summer 2019).
- Provided program information and requested data (e.g., fish counts) to cooperators, researchers, power companies, and the public
- Administered grant/program agreements and supervised Student Conservation Association (SCA) Interns: Kristin Lavasseur (10/1/18 – 12/15/18), Gabriel Soto and Aaron Heisey (4/1/19 – 8/25/19), and an unpaid student intern Ryan Judd (Westfield State University, 5/7/19 – 7/15/19). A second paid SCA intern, Jacob Rawlings started in early September 2019 (cost covered *gratis* by SCA) of this report period.
- Transferred 145 American Shad, from the Holyoke Fish Lift, to the Farmington River (CT), upstream of the Rainbow Dam in June.
- Captured and transferred 275 Blueback Herring from Wethersfield Cove (CT) into the Manhan River, upstream of Easthampton Dam (MA).
- Seasonal staff were trained in standardized culvert assessment protocols by Phil Herzig (USFWS Fish Biologist) and completed several dozen assessments in area watersheds.
- Initiated spring river herring otolith reading/age determinations in late summer of 2019
- In mid-August 2019 initiated the third year of the Juvenile American Shad Assessment

Project with MADFW, ongoing through the end of this report period (September 30, 2019).

Cooperative Research

- Provided field support to UMASS/USGS Conte Lab, PhD student conducting research on larval development of river herring under different temperature and feeding regimes at Cronin Aquatic Resource Center
- Served as USFWS project officer and cooperator the for U. S. Geologic Survey University of Massachusetts and Conte Fish Research Laboratory (CAFRC), Environmental Factors Controlling Juvenile River Herring Productivity and Emigration (2019-2022), USFWS Science Support Program
- Collaborated with Dr. Eric Schultz (University of Connecticut) on research of female BBH gonads and oocyte (gonads removal, weights, tissue subsampling and imaging). A total of 747 females (all females brought to lab) had this additional laboratory processing.

Outreach

- Provided presentation on office activities and fish status and trends to Westfield State University (WSU, 11/27/18) and represented the USFWS at the WSU Environmental Career event (12/4/18).
- Provided a presentation on migratory fish status, trends, management, and research to the Deerfield River Chapter of Trout Unlimited 12/20/18.
- Produced the CT River Basin Fishway Counts report and distributed 2-3 times a week in spring season (frequently later in year) electronically and posted updates on the Office web site maintained databases (Appendix A).

Acknowledgements

Many people have contributed to the work accomplished by this office in the report period that I want to recognize and thank. Darren Desmarais served as the sole permanent staff (Fish Biologist) for the CTRFWCO and contributed greatly to the office's accomplishments in many areas, particularly on the river herring project. Rebecca Gleason (Administrative Assistant for three stations), was invaluable in her handling of administrative tasks over the year, retiring in June of 2019. Kristen Lavasseur assisted in fall juvenile shad assessment field and lab work of 2018 from SCA. Aaron Heisey and Gabriel Soto were essential seasonal field staff (hired through the SCA) that worked on many activities from April through August. Jacob Rawlings was our third paid intern (SCA) starting in September 2019. Ryan Judd was an unpaid student intern from Westfield State University that contributed over 200 hours of time for school credit. Jeni Menendez, a trained biologist, volunteered approximately 60 hours in the spring in field and lab work. Many other people assisted us in our work this year including other USFWS program staff.

Don Pugh has continued to provide significant technical support for the resource agencies' efforts on hydropower relicensings and ongoing fish passage activities at facilities like Holyoke Dam. Don's contributions in data analyses, review of power company reports and plans and discussion are highly valued by the agencies. Katie Kennedy (The Nature Conservancy) also continued to make important technical contributions on FERC activities and other aquatic conservation initiatives. The Connecticut River Conservancy, from the Director Andy Fisk to its field staff (Andrea Donlon and Kathy Uffer), have provided ongoing staff support for field activities and important technical support (FERC and other area) over the course of the year. Matt Devine (UMass PhD student) provided valued guidance and lab space that made our juvenile shad otolith work possible.

Other thanks for assisting in the accomplishments over this report period go to:

State fishery agencies -

- Connecticut: Steve Gephard, Kevin Jobs, Tim Wildman, Jacque Roberts, and staff
- Massachusetts: Caleb Slater, Ben Gahagan, Steven Mattocks, and Brian Keleher
- New Hampshire: Matt Carpenter, Gregg Comstock
- Vermont: Lael Will (and her seasonal technicians), Jeff Crocker, Eric Davis, Peter McHugh

Federal agencies –

- USFWS: Melissa Grader, Phil Herzig, Brett Towler, Julianne Rosset, Andy French, and David Perkins
- NOAA Fisheries: Bill McDavitt and Julie Crocker
- USGS Conte Lab: Ted Castro-Santos, Alex Haro, Steve McCormick, Micah Kieffer

The Anadromous Fish Program and The Connecticut River Atlantic Salmon Commission

The administration of the interjurisdictional cooperative effort to restore diadromous fish species to the Connecticut River basin is accomplished through the Connecticut River Atlantic Salmon Commission (the Commission). During the period from 1967-1983 (prior to the Commission), restoration of anadromous fish, primarily Atlantic Salmon and American Shad, on the Connecticut River was guided by the Policy Committee and the Technical Committee for Fisheries Management of the Connecticut River Basin. The importance of this formally-structured, coordinating and regulatory body to the restoration program was recognized in 1983 when Congressional consent was given to the Connecticut River Basin Atlantic Salmon Compact, Public Law 98-138. The enabling legislation was re-authorized for another 20 years in 2002. This law, originally passed by the legislative bodies in each of the four basin states, created the Commission and conveys Congressional support to an interstate compact for the restoration of anadromous fish to the Connecticut River Basin. The Commission is comprised of ten Commissioners (Table 1) including a high-level government employee and a public sector representative appointed by the governor of the appropriate state, and the Northeast Regional Directors of both the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) also referred to as NOAA Fisheries.

The Commissioners act on policy matters and are advised on scientific and technical matters by a Technical Committee. The Technical Committee is comprised of senior staff biologists from each Commission member agency, the U.S. Forest Service (USFS), and the Massachusetts Division of Marine Fisheries (Table 2). The Technical Committee has nine subcommittees, with specific areas of responsibility (American Shad, River Herring, Atlantic Salmon, American Eel, Sturgeon, Sea Lamprey, Fish Passage, Habitat, and Fish Culture). Other experts and cooperators from the member agencies including the U.S. Geological Survey, Conte Anadromous Fish Research Center (CAFRC), Trout Unlimited, The Nature Conservancy, Connecticut River Conservancy, private industry, and others participate with the subcommittees and Technical Committee as needed. The Connecticut River Coordinator (Coordinator), also the Connecticut River Fish and Wildlife Conservation Office Project Leader, is an employee of the USFWS, acts as the Executive Assistant to the Commission and the Secretary for the Technical Committee and is the USFWS Technical Committee representative.

The Coordinator is responsible for assisting on coordination of state and federal activities, providing; technical expertise, project development and implementation of fish population assessments, restoration, management, and research programs, program evaluation, assist in the USFWS Ecological Services Division on Federal Power Act with FERC, and conduct advocacy and outreach of the cooperative diadromous fish restoration program in the Connecticut River watershed (Figure 1). The Coordinator also organizes meetings, identifies priorities, develops initiatives and plans, implements them, and maintains and develops partnerships to accomplish objectives.

Fish species under restoration and enhancement in the Connecticut River basin include American Shad, Blueback Herring, Sea Lamprey, American Eel, and Alewife, primarily addressed by

efforts to provide safe, timely, and effective upstream and downstream passage to historic habitats as well as measures to improve habitat quality (e.g., address rapid, large scale fluctuations in sub-daily discharge from hydropower operations). Shortnose Sturgeon, a federally endangered species, is under recovery and continues to be monitored, studied, and protected in a variety of ways, some of which will be covered in later text. Atlantic Sturgeon are also present in the lower river and are federally protected.

In 2019, only three adult Atlantic Salmon were trapped at Holyoke Dam and released to continue upstream. Based on the last (final) large-scale stocking of fry that occurred in 2013, these fish are believed to originate from Connecticut's Legacy Program or possibly from natural production. The CTDEEP continues fry stocking with its Atlantic Salmon Legacy Program. In 2019, a total of 130,103 unfed fry were stocked in the Salmon River basin and 53,454 unfed fry and 157,201 fed fry were stocked in the Farmington River basin. This effort maintains a presence of this species in the basin and serves many other CTDEEP objectives.

The CRASC continues to serve as an important mechanism to maintain communication and coordination on migratory fish restoration and management activities in the Connecticut River basin. Given the current status of diadromous species (both in-basin and coast wide), the main stem hydropower facilities in FERC relicensing process, and recent Holyoke Dam downstream passage (Settlement Agreement) measures being completed and under evaluation, there is a need and value of a basin-wide coordinated management approach.

The CRASC meets at least twice each year and the Technical Committee meets as frequently as needed. This report period, the Commission met on December 10, 2018 and on August 8, 2019. The Technical Committee met on December 3, 2018 and on July 16, 2019. Dr. Rick Jacobs was appointed as Chief of the Natural Resources Bureau Connecticut DEEP this period following Bill Hyatt's retirement. Dr. Andrew Fisk (CRASC Vice Chair), served as Chair of the Commission for the meetings in this period.

CRASC scheduled meetings are open to the public, contact Ken Sprankle at ken_sprankle@fws.gov or at 413-548-9138 ext. 8121, to receive notices for scheduled meetings. Interested citizens are given the opportunity to provide input and area news publishers are notified of scheduled Commission meetings via email. Minutes of both Commission and Technical Committee meetings, once approved are available and posted on the Connecticut River FWCO website, https://www.fws.gov/r5crc/. Any one requiring hearing assistance should contact Ken Sprankle at least 3 weeks in advance of scheduled meetings, so appropriate arrangements can be made.

Table 1. Connecticut River Atlantic Salmon Commission Membership (as of September 2019).

Connecticut River Atlantic Salmon Commission	
Federal	**U.S. Fish and Wildlife Service** *Wendi Weber* Regional Director, Region 5 *Sherry White, alternate*
	National Marine Fisheries Service *Michael Pentony* Northeast Administrator *Kimberly Damon-Randall, alternate*
Connecticut	**Connecticut Dept. of Energy and Environmental Protection** *Rick Jacobs* Chief, Bureau of Natural Resources *Stephen Gephard, alternate*
	Public Sector Representative *vacant*
Massachusetts	**Massachusetts Division of Fisheries and Wildlife** *Mark Tisa* Director *Todd Richards, alternate*
	Public Sector Representative *Andrew Fisk (Vice Chair)*
New Hampshire	**New Hampshire Fish and Game Department** *Glenn Normandeau* Executive Director *Scott Decker, alternate*
	Public Sector Representative *Duncan McInnes*
Vermont	**Vermont Department of Fish and Wildlife** *Louis Porter* Commissioner *Eric Palmer, alternate*
	Public Sector Representative *Peter H. Basta*

Table 2. Connecticut River Atlantic Salmon Commission Technical Committee Membership.

Connecticut River Atlantic Salmon Commission Technical Committee	
Federal	**U.S. Fish and Wildlife Service** *Kenneth Sprankle*
	National Marine Fisheries Service *William McDavitt*
	U.S. Forest Service *Dan McKinley*
Connecticut	**Connecticut Dept. of Energy and Environmental Protection** *Stephen R. Gephard*
Massachusetts	**Massachusetts Division of Fisheries and Wildlife** *Caleb Slater* (Chair)
	Massachusetts Division of Marine Fisheries *Ben Gahagan*
New Hampshire	**New Hampshire Fish and Game Department** *Matthew Carpenter*
Vermont	**Vermont Department of Fish and Wildlife** *Lael Will*

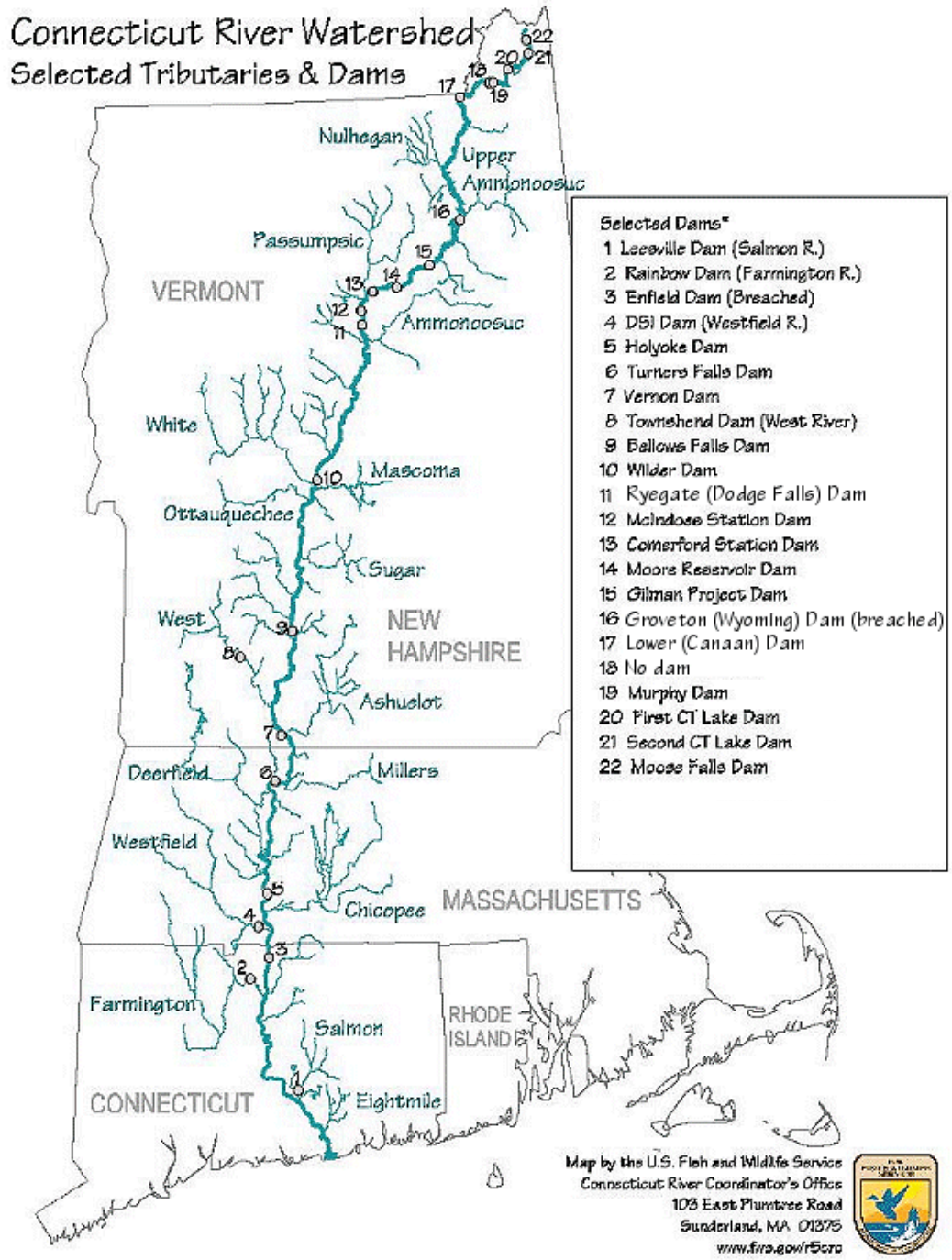


Figure 1. Connecticut River basin with major tributaries and main stem dams.

Coordination and Technical Assistance Funding

The Connecticut River Fish and Wildlife Conservation Office (CTRFWCO), under the USFWS' Wildlife and Sport Fish Restoration Program's F-100-R-36, for this report period, received $15,000 from three state fishery agencies through their annual Sport Fish Restoration Program apportionment (F-100-R). The Massachusetts Division of Fisheries and Wildlife (MADFW) has opted to reimburse the USFWS via the signed Memorandum of Understanding, using agency-generated funds ($5,000). The grant project was assessed an USFWS administrative overhead fee leaving $16,270 available. The Office utilized the Sport Fish Restoration funds, MADFW funds, and USFWS Fisheries Program base funding for an operational budget totaling $320,330 for fiscal year 2019. The Sport Fish Restoration and MADFW funds were fully drawn down to pay expenses for the CTRFWCO building/grounds, office/operations (electricity, phone/data), storage facility and vehicle maintenance expenses, allowing USFWS non-salary funds to be applied in other operational areas.

Station total: $320,330 **States (F-100-R):** $16,270 **FWS Federal:** $304,060

Project Accomplishments

The Connecticut River Fish and Wildlife Conservation Office enhanced the Commission and States' ability to plan, coordinate, manage, evaluate, and implement restoration programs through a variety of activities, some of which are described in greater detail in the following sections. Please note that data presented in this report have been reviewed to the extent possible, but is subject to change and should be considered provisional. **Use of any presented data should be discussed with the Coordinator to avoid potential issues with use, analyses, and/or interpretation**.

Coordination activities, select details:

The Coordinator provided administrative support to the CRASC Commission and Technical Committee as the Executive Assistant and Secretary respectively, making meeting arrangements, establishing agendas, developing reports, distributing information, drafting correspondences, tracking finances, and recording and distributing minutes of Commission and Technical Committee meetings. The Coordinator participated on the CRASC Fish Passage, Shad and River Herring, Sea Lamprey subcommittees during this report period. The Coordinator served as the Chair for Shad and River Herring subcommittees and issued the Annual Fish Passage Notification letters on behalf of CRASC to main stem hydropower operators by March.

Fisheries Management, Restoration, Assessment, and Technical Assistance: additional select information

For the sixth consecutive year, a large-scale population assessment program for river herring was initiated by this office in early April, utilizing boat electrofishing as the primary sampling gear. Study objectives include: 1) obtain a minimum whole fish sample of 80 Blueback and Alewife for age structures, per target sample location/event; 2) obtain baseline demographic data on all

sampled river herring (species, length, weight, sex, spawning condition); 3) derive relative abundance/catch measures using repeated standardized (time) sample runs; 4) conduct surveys across a broad geographic range of spawning aggregations and over the duration of the runs (April-June), representing spatial and temporal variations for both species; 5) determine fish ages from otoliths and spawning history from scale examinations; and 6) utilize standard stock assessment procedures and statistics to describe status and trends. This work was developed and is being conducted to address identified priority data needs, specific to the Connecticut River and coast-wide, as described in the Atlantic States Marine Fisheries Commission's River Herring Benchmark Stock Assessment Report released in May 2012 and the most recent August 2017 release of the River Herring Stock Assessment Update (http://www.asmfc.org/species/shad-river-herring), that concludes "…*river herring continue to be depleted on a coast wide basis and near historic lows*." This assessment program is a long-term commitment by the CTRFWCO and will continue in future years. The project provides the data and analyses required for science-based restoration and management of these species.

Table 3. An annual summary of the river herring population assessment program's effort, catch, and laboratory processing total by species (2013-2019).

	2013	2014	2015	2016	2017	2018	2019
Number of sampling dates	18	21	20	25	26	23	27
Total sample runs	81	124	114	145	145	147	147
Total electrofishing seconds	41,177	55,736	56,025	71,845	68,353	69,835	80,473
Total bluebacks captured	714	2,593	1,448	1,586	2,650	2,396	3,456
Total alewives captured	107	220	258	586	200	366	243
Blueback Herring otolith/scale – lab	501	655	622	730	1,192	991	1,473
Alewife otolith/scale - lab	103	188	165	461	190	284	217

There was an increase in the number of sample days in 2019, 27 versus 23 in 2018, with an equal number of sample electrofishing runs (or transects) between the years. In 2019, sampling was initiated on April 2 in the Mattabesset River and Alewife were sampled on that first outing as is often the case. The incidences of high catch rates occurred on more sampling runs in 2019 contributing to differences in "total time" shown in Table 3. When sampling runs encounter high catch rates (>60 fish collected) the run duration is shortened, this occurred on 22 runs in 2019 versus 18 runs in 2018 and 16 runs in 2017 and is reflected in subsequent catch rate summaries and comparisons. Sampling concluded on June 10, 2019 (similar to previous years) with sampling at Chicopee and Westfield rivers.

Blueback Herring catch rates over the sample season were highly variable, with the first occurrence of the species in sampling observed on April 17, 2019 at Farmington River (Figure 2). Mean catch rates for Blueback Herring exhibiting an interesting mid May decrease following very high catch rates the first week of May. The third week of May shows a return to high catch rate levels for the Farmington River but not Wethersfield Cove. There were no exceptional "high discharge" events that occurred in this mid May period.

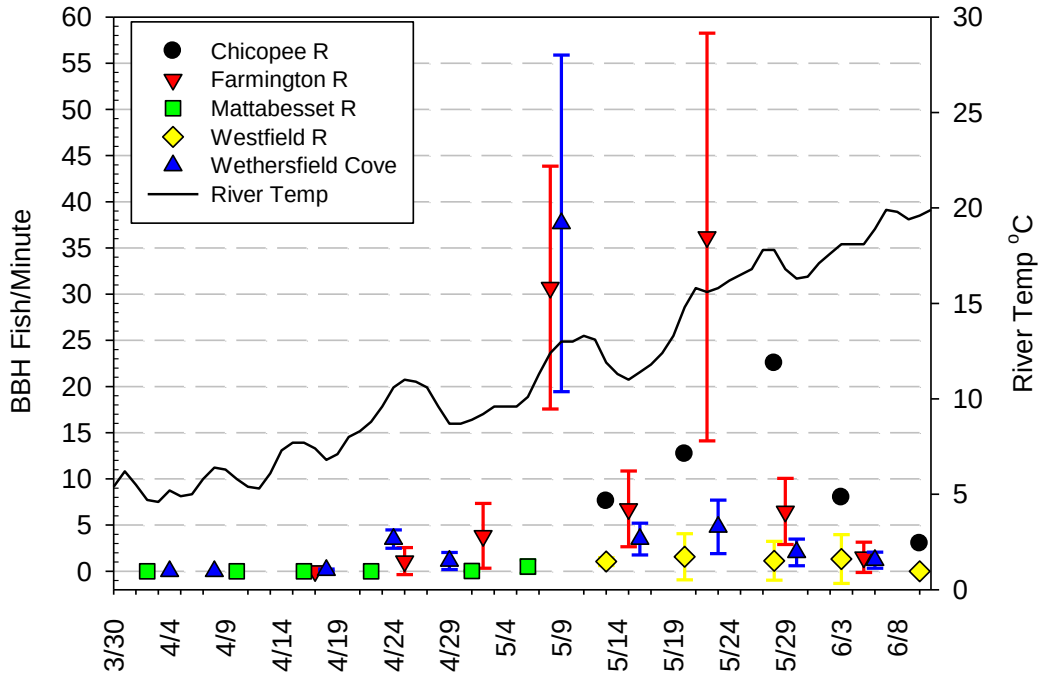


Figure 2. Adult Blueback Herring relative abundance expressed as mean fish/minute ± standard deviation, by sample area and date for 2019 season. Reported daily mean water temperature, U.S. Geological Survey, Middle Haddam, CT.

Catch rates (fish/minute) for Blueback Herring among four primary sites utilized by this species, excluding the Mattabesset River, as an annual mean with the associated standard deviations, are provided in Table 4. Variability in catch rates within and among sites is high and is reflected in the reported variance for each year. The 2019 annual mean BBH catch rate (four sites) is the second highest in the time series.

Table 4. Mean relative abundance (fish/min) catch rates for Blueback Herring, using individual run catch rates, once bluebacks were first encountered (i.e. 4/17/19), at Wethersfield Cove, Farmington River, Westfield River, and Chicopee River.

Year	BBH Mean fish/min	SD	Holyoke Fish Lift BBH - annual counts
2013	2.10	5.63	976
2014	8.51	12.96	647
2015	2.74	3.70	87
2016	2.18	2.57	137
2017	4.01	7.11	922
2018	4.30	7.01	1,060
2019	6.70	12.75	5,052
Mean	*4.36*		

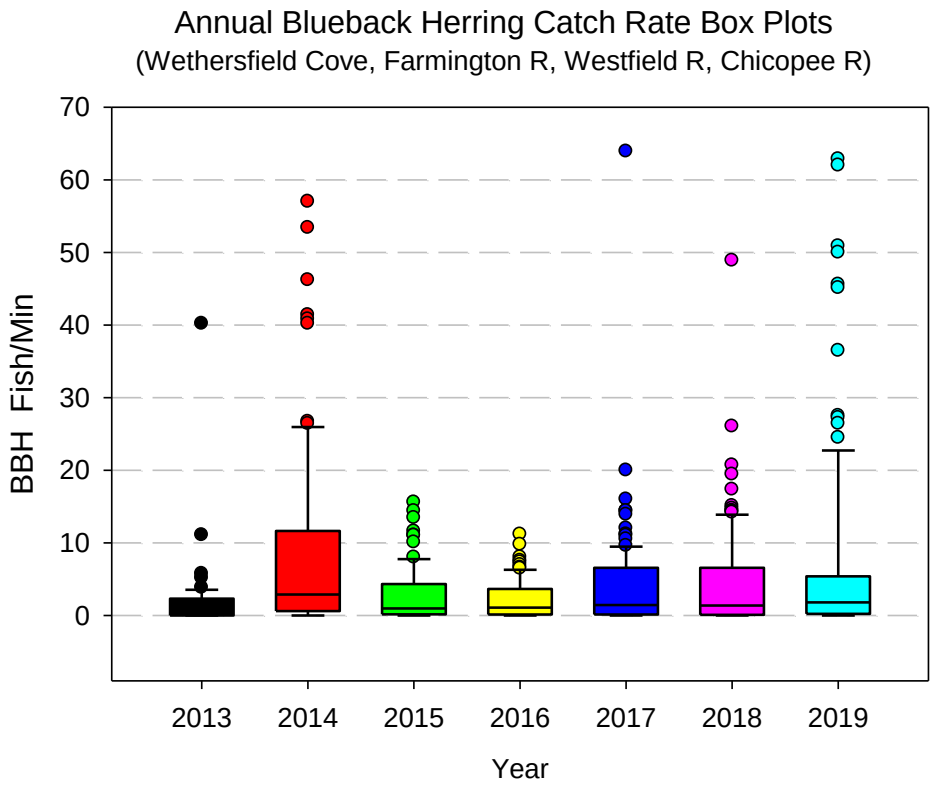


Figure 3. Box and whisker plots by year, for Blueback Herring catch rates, using all individual runs, based on the date of first capture for the four sample areas.

Summary results for annual sample totals and mean catch rates for Alewife (ALW) are presented with some censoring of data including: 1) for f/min - use of only catch data from the Mattabesset and Wethersfield Cove; and 2) use of only sample dates beginning once ALW have been confirmed as present at any site and censoring of "0" from Wethersfield Cove based on last week of Alewife present there (Table 4). Unlike BBH, the first sampling dates of the year have yielded catches of Alewife in all years, at low levels of abundance. The sole exception was in 2015, when the Salmon River Cove was sampled first on April 9, producing no fish, but on the following week the Mattabesset was first sampled and ALW were captured. As the Mattabesset River is sampled typically only to the end of April, all dates are used for catch rates of ALW. However, as the Wethersfield Cove site is sampled for the full season, ALW become rare (single individuals) and eventually absent in May. Accordingly, the catch data for ALW were also censored for Wethersfield Cove dates when "zero" ALW are captured in the month of May in all years (typically early to mid-May). Alewife catch has varied among sites over the seven years, with the Mattabesset River accounting for 72% of the cumulative sample total followed by Wethersfield Cove (21%). The exceptionally high river discharge of April, highest in our sampling history, is reflected in Table 5. It is strongly suspected those flooded habitat conditions resulted in biased (low) catch rates and extremely high variability (CV).

Table 5. A summary of total annual Alewife (ALW) catch, among all sampling locations, date of first ALW catch, arithmetic mean catch rate by year for ALW (Mattabesset River and Wethersfield Cove sites) with standard deviation and coefficient of variation. Mean calculated from sample date mean f/min (based on all runs of each date).

Year	ALW captured (n)	Date of first ALW capture	Mean ALW f/min 2 primary areas	S.D.	C.V. (%)	Mean April Discharge[A]
2013	107	4/08/13	0.41	0.48	117	33,360
2014	220	4/07/14	0.50	0.75	150	54,670
2015	257	4/15/15[B]	0.68	1.06	156	43,350
2016	586	3/30/16	1.01	1.63	162	23,290
2017	200	3/29/17	0.37	0.59	160	31,650
2018	366	4/05/18	0.92	0.70	76	37,870
2019	243	4/02/19	0.22	0.82	372	61,310
Total	1,979					

[A] Mean discharge provided by USGS Thompsonville, CT Gage

[B] First sample date for Mattabesset that year, later than typical

A summary of river herring mean total lengths (mm) with standard deviations are shown in Table 6, by sex, for each species, by year. A one-way ANOVA detected significant differences ($P < 0.001$) among annual mean total lengths for both male and female Blueback Herring and Alewife. Post-hoc pairwise comparisons (Holm-Sidak) detected significant differences at $P < 0.05$ as indicated in Table 6, between years (within same species/sex).

Table 6. A summary of annual mean total length (mm) with standard deviations (SD), for all processed Blueback and Alewife, by sex, for the survey years of 2013 – 2018. ANOVA tests were followed by pairwise comparisons by species and sex. Significantly different pairwise comparisons ($P < 0.05$) are indicated by year letter assignment.

	Blueback				**Alewife**			
	Male		Female		Male		Female	
Year	Mean TL mm (± SD)	Signf. Diff.	Mean TL mm (± SD)	Signf. Diff.	Mean TL mm (± SD)	Signf. Diff.	Mean TL mm (± SD)	Signf. Diff.
2013[A]	253.8 (12.1)	C, D, E, F	264.9 (12.6)	C, D, E, F	261.6 (15.8)	C, D, F	287.7 (16.2)	B, D, F
2014[B]	253.8 (11.4)	C, D, E, F	264.9 (13.2)	C, D, E, F	266.2 (10.8)	C, D	276.1 (15.5)	A, C, D
2015[C]	263.0 (10.4)	A, B, D, E, F	277.8 (11.7)	A, B, D, E, F	273.1 (11.7)	A, B, E	287.9 (12.4)	B, D, F
2016[D]	265.2 (13.3)	A, B, C, E, F	281.3 (13.0)	A, B, C, E, F	270.7 (18.0)	A, B, E	286.4 (19.0)	B, D, F
2017[E]	257.5 (12.7)	A, B, C, D	271.7 (14.9)	A, B, C, D, F	265.0 (18.3)	C, D	278.4 (21.4)	A, C, D
2018[F]	256.7 (12.9)	A, B, C, D	268.4 (14.7)	A, B, C, D, E	269.5 (14.9)	A	280.0 (18.1)	A, C, D
2019	260.4 (9.9)		273.3 (13.4)		274.4 (11.0)		291.3 (15.0)	

All 2018 otolith samples for both Blueback (n=991) and Alewife (n=284) were read for age determination by March 2019 and those data and analyses (with full time series) were used in the CRASC Research Forum presentation and a presentation for the Southern New England Chapter of the American Fisheries Society in June 2019. Otolith examination for the 2019 samples was initiated in the late summer, during this report period. In addition, seasonal staff cleaned and mounted scale samples from the 2019 lab processed fish: Blueback Herring (n=1,473) and Alewife (n=217). Eight scales from each sample were cleaned and mounted on glass slides and then examined by microfiche projector for the presence of previous spawning marks (defined by scale erosion mark presence). Based on two reader, independent reads and then consensus agreement, assignments on first time (virgin) or repeat spawn (defined frequency) were determined. Data and analyses for Blueback Herring, for 2019, at the four primary sites are shown in Figure 4. The percentage of virgin fish (sexes combined) is consistent with recent years and continues to exhibit a gradient from south to north, of increasing virgin fish. Sex specific rates are also shown in the figure (panels).

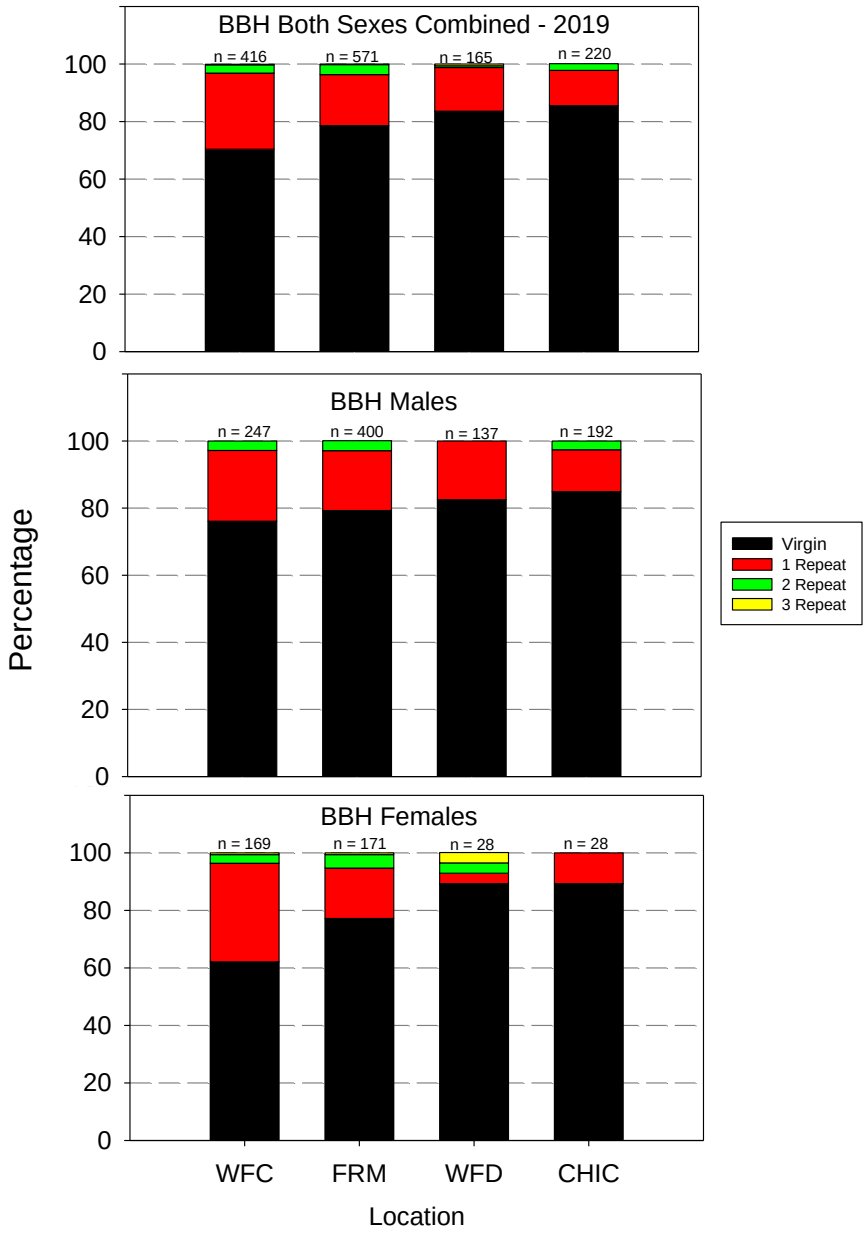


Figure 4. Spawning history of Blueback Herring (sexes combined and by sex) sampled in 2019 at the four primary sites; Wethersfield Cove (WFC), Farmington River (FRM), Westfield River (WFD) and Chicopee River CHIC.

Length frequency plots describing size distributions by sex, over time, have been developed in aggregate and at the site-specific level. Shifts in the annual size distributions is apparent for the period 2013 -2019 for the Farmington River Blueback Herring example (Figure 5). Additional information is required for considering the extent of influence by year class strength, which has demonstrated the 2010 year class' disproportion presence as age-4, age-5 and age-6, that explains the increase in size frequency through 2016.

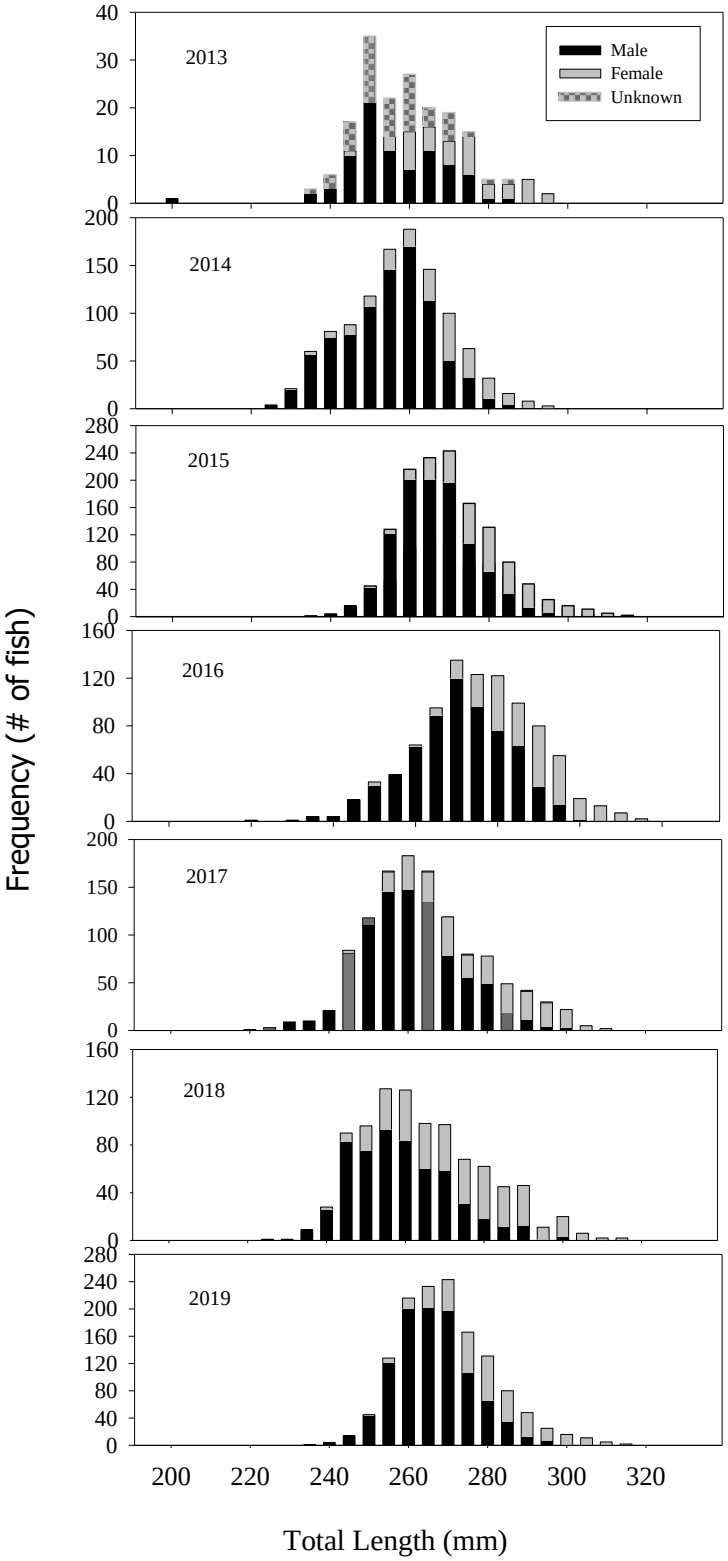


Figure 5. Length frequency distributions, based on total length, by sex (stacked) for Blueback Herring sampled annually (2013-2019 - panels) from the Farmington River.

- A summary of American Shad transfers from Holyoke Fish Lift's trapping and transfer facility to support restoration efforts in and out-of-basin, with stocking locations, and for

research are provided in Table 8. This Office moved two loads of American Shad from Holyoke Fish Lift to the Farmington River upstream of the Rainbow Dam, in support of CTDEEP efforts to increase juvenile production upstream of that dam. The Rhode Island Department of Fish and Wildlife released 318 shad in the Ashuelot River upstream of the third hydroelectric dam in Hinsdale NH (CRASC requirement for their out-of-basin transfers to the North Attleboro National Fish Hatchery. In addition, USGS Conte Lab used American Shad for research on fishway entrance weir configurations, with the subsequent release of these study fish immediately upstream of Turners Falls Dam.

Table 8. American Shad transfers from Holyoke Fish Lift facility in 2019, release location, transferring agency and numbers.

Release Site	State	Agency	Number Moved	Number Released[A]
Ashuelot River	NH	RIDFW	240	240
Lab then Barton Cove	MA	USGS Conte Lab	1,295	1,295
Farmington River	CT	USFWS CTRFWCO	145	145
CT restoration rivers	CT	CTDEEP	499	499
Pawcatuck River	RI	RIDFW	243	243
		Totals	2,422	2,422

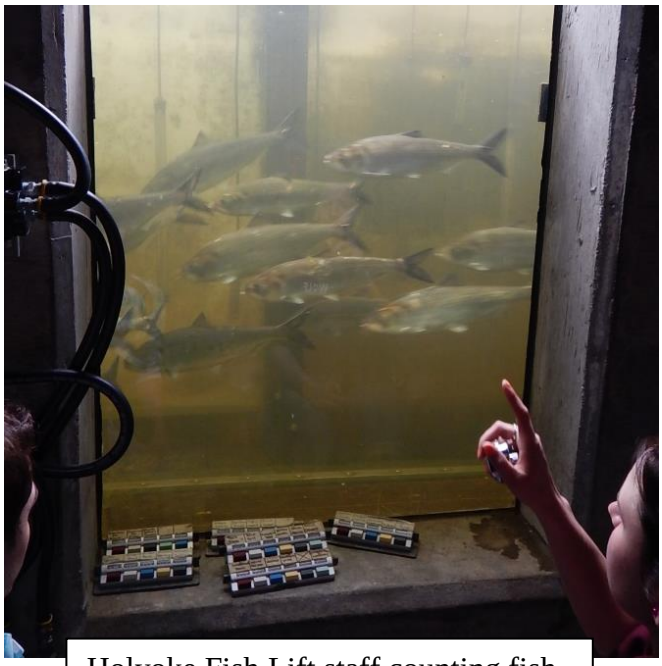
[A] In many cases there were no provided data on release mortalities so the number released is artificially high. In addition, note that Conte Lab shad were primarily released alive in Barton's Cove following ~ 48 hours of passage tests in the flume building.

The CTRFWCO also captured and transferred 254 Blueback Herring from Wethersfield Cove (CT) to the Manahan River, Easthampton (MA), upstream of the Manhan Dam/fishway.

The Office continued to maintain databases on migratory fish restoration activities. Daily fish counts at different dams were entered into databases. Fish counts were updated in-season at frequent intervals during the spring, with email notifications to individuals and postings to the office's web site (Appendix A).

Program Results

The Connecticut River Fish and Wildlife Conservation Office collected and reported information relating to the activities and accomplishments occurring in the Connecticut River basin diadromous fisheries restoration program. Note some of the data presented here are preliminary, not all counts were final at the time of this report (Appendix A).



Holyoke Fish Lift staff counting fish

Migratory Fish Returns

American Shad - A total of 318,707 adult American Shad were counted in 2019 at all first barrier passage facilities in the basin. A total of 314,361 American Shad were passed upstream of the Holyoke Dam, Massachusetts (river km 138), in 2019 through its two fish lifts, this is a 14% increase from 2018 (Figure 4). The mean passage count at Holyoke for the period 1976-2017 is 309,041 (±SD 131,363). The 25th and 75th percentile values for passage counts are 196,084 and 376,777 respectively. The Holyoke Fish Lift had a late opening on 5/6/19 due to a combination of high river discharge (spill) and cool water temperatures and then operated with little disruption (high flow/turbidity) the remainder of the "upstream" passage season (7/15). The highest single passage date for shad occurred on 6/1/19 with 48,870 shad counted passing (Figure 5).

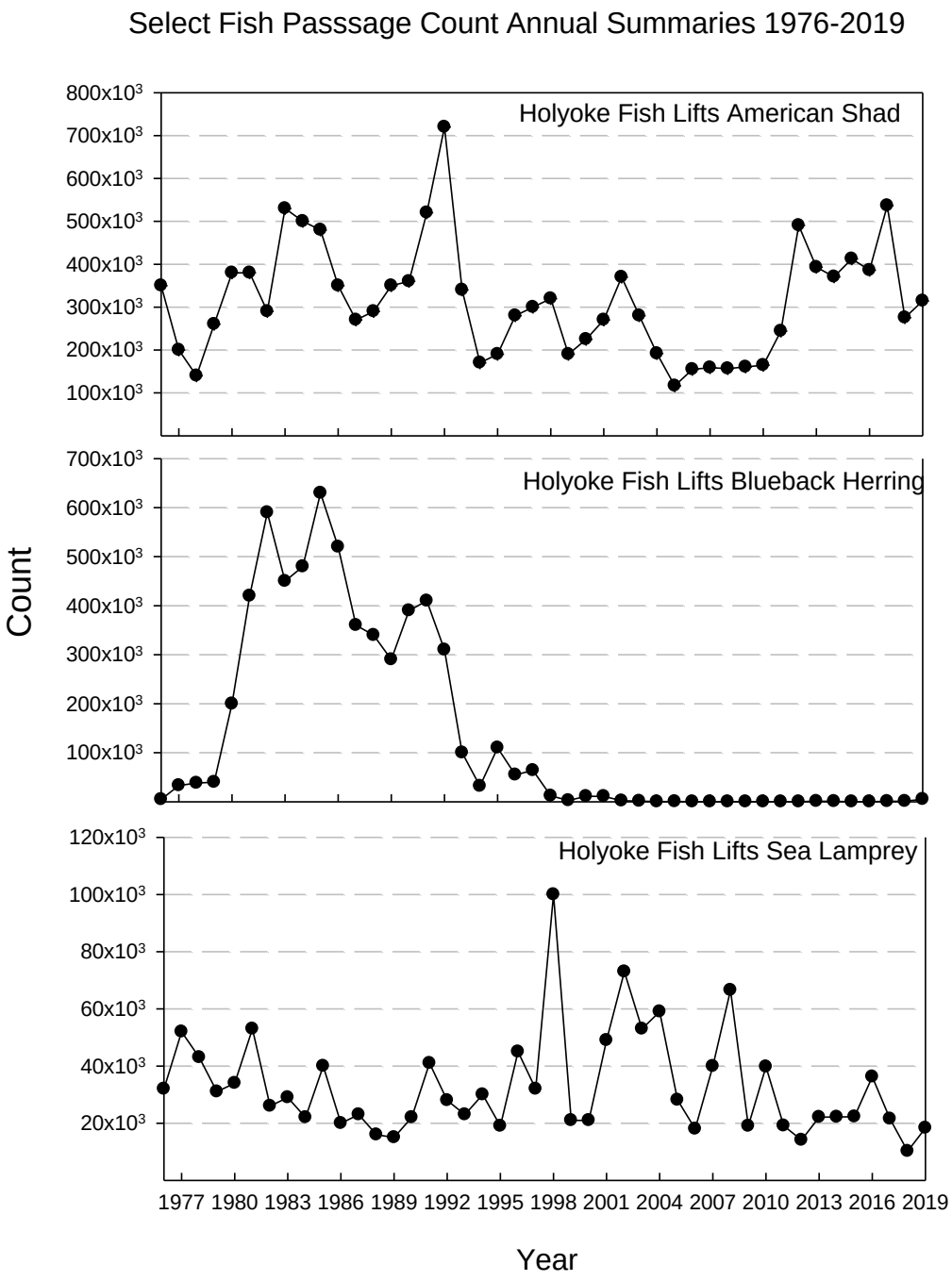


Figure 4. Select count summary of Holyoke Fish Lifts passage counts for American Shad, Blueback Herring and Sea Lamprey (1976-2019). Fish passage (counts) are affected by structural and operational changes at both dams and fishways and by environmental conditions (temperature and flow/spill) within year and among years.

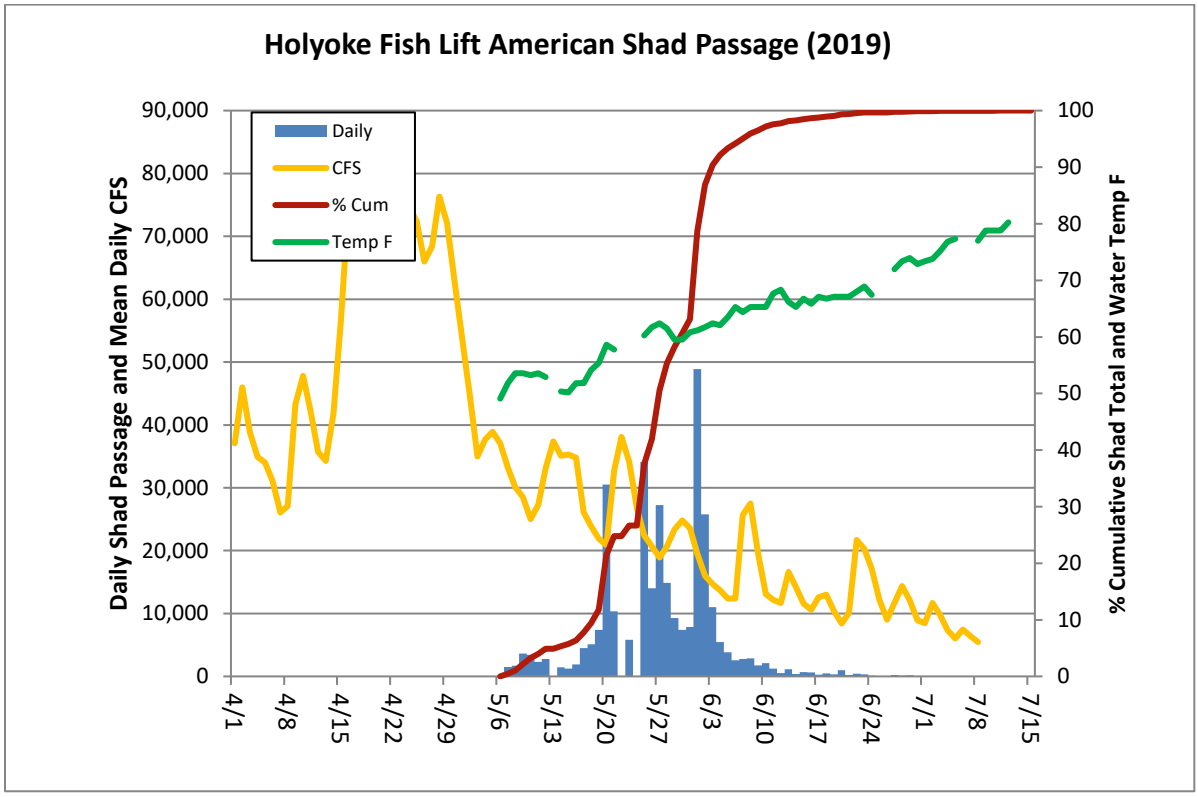


Figure 5. Daily American Shad passage counts from Holyoke Fish Lifts with water temperature and river discharge (USGS) data included for the period April 1 to July 15, 2019.

A total of 4,064 American Shad were passed upstream of the West Springfield Fish Ladder in 2019 on the Westfield River, which is a decrease from the 5,752 shad counted in 2018 and greater than the long-term mean of 3,300. The record high American Shad passage count at that facility was 10,300 in 2012. A total of 276 American Shad were passed upstream of the Rainbow Dam Fishway on the Farmington River in Connecticut, a fishway with known upstream passage issues for this species.

Of the American Shad passed upstream of the Holyoke Dam, 22,649 shad were counted passing the Gatehouse Ladder at Turners Falls Dam in 201, a substantial decrease from the 43,136 passed in 2018, in spite of the increased passage count at Holyoke (Table 9). The Turners Falls Dam and power canal is a three-fishway complex. Fish must first pass either the Cabot Station Ladder (into the power canal) or the Spillway Ladder, located at the base of the dam and upstream end of the "bypassed reach." Fish passing the Cabot Ladder exit into the lower power canal that requires finding one of two entrances to the Gatehouse Ladder at the upstream end of this 2.1 mile long canal. Spillway Ladder (at the dam) passed fish may go directly to the entrance of the Gatehouse Ladder, but as in the case of all ladders, have opportunities to drop back, including into the canal. At Cabot Station Ladder, a total of 21,804 shad were counted passing into the power canal. At the Spillway Ladder, a total of 13,150 shad were counted passing. As mentioned, the number of shad successfully finding and entering the Gatehouse Ladder entrances from the canal (and subsequently passing) is unknown and impacted by several dynamic factors of the canal's operation. Similarly, the number of shad counted passing the Spillway Ladder and successfully passing is also unknown but is believed to be a high rate,

for that engineered/connected route for fish achieving that level of advancement in the passage process.

Overall, the 2019 passage number at Gatehouse Ladder (requiring passage at noted two other ladders) as a percentage of American Shad passed at Holyoke was only 7.2% or half of the 15.6% (highest in time series) observed in 2018 (Table 9). The 2017 CRASC Shad Management Plan has a minimum passage objective of 397,000 American Shad for the Turners Falls Project, or ~58% of the minimum target passage objective at Holyoke, based on upstream habitat. The number of shad passed at Turners Falls in 2019 was 5.7% of the CRASC Plan minimum escapement target.

At the next upstream barrier, Vernon Dam (Vernon, Vermont), the single fish ladder passed 12,872 American Shad, down from the 31,724 passed in 2018, based partly on the very low passage at Turners Falls. Vernon Dam Ladder passed 56.8% of the American Shad counted passing from the Turners Falls Gatehouse Ladder in 2018. However, the actual count number is well below (14% CRASC escapement) the minimum escapement target of 227,000 American Shad in the 2017 CRASC Plan for that facility (Table 9).

Table 9. American Shad fishway passage counts for the period of 1980 – 2019, for Holyoke Dam, Turners Falls Dam (Gatehouse Ladder), and Vernon Dam.

Year	HFL Passed	Gatehouse Passed	% Gate vs. HFL #	Vernon Passed	%Vern vs. Gate #
1980	380,000	298	0.1		
1981	380,000	200	0.1	97	48.5
1982	290,000	11	0.0	9	81.8
1983	530,000	12,705	2.4	2,597	20.4
1984	500,000	4,333	0.9	335	7.7
1985	480,000	3,855	0.8	833	21.6
1986	350,000	17,858	5.1	982	5.5
1987	270,000	18,959	7.0	3,459	18.2
1988	290,000	15,787	5.4	1,370	8.7
1989	350,000	9,511	2.7	2,953	31.0
1990	360,000	27,908	7.8	10,894	39.0
1991	520,000	54,656	10.5	37,197	68.1
1992	720,000	60,089	8.3	31,155	51.8
1993	340,000	10,221	3.0	3,652	35.7
1994	170,000	3,729	2.2	2,681	71.9
1995	190,000	18,369	9.7	15,771	85.9
1996	280,000	16,192	5.8	18,844	116.4
1997	300,000	9,216	3.1	7,384	80.1
1998	320,000	10,527	3.3	7,289	69.2
1999	190,000	6,751	3.6	5,097	75.5
2000	225,000	2,590	1.2	1,548	59.8
2001	270,000	1,540	0.6	1,744	113.2
2002	370,000	2,870	0.8	356	12.4
2003	280,000		Not available	268	
2004	192,000	2,192	1.1	653	29.8
2005	116,511	1,581	1.4	167	10.6
2006	155,000	1,810	1.2	133	7.3
2007	158,807	2,248	1.4	65	2.9

2008	156,492	4,000	2.6	271	6.8
2009	160,649	3,813	2.4	16	0.4
2010	164,439	16,422	10.0	290	1.8
2011	244,177	16,798	6.9	46	0.3
2012	490,431	26,727	5.4	10,386*	38.9
2013	392,494	35,293	9.0	18,220	51.6
2014	370,506	39,914	10.8	27,706	69.4
2015	412,656	58,079	14.1	39,771	68.5
2016	385,930	54,069	14.0	35,513	65.7
2017	536,670	48,727	9.1	28,682	58.9
2018	275,232	43,146	15.6	31,724	73.5
2019	314,361	22,649	7.2	12,872	56.8

*an example of a fishway issue that was identified (telemetry study), resolved (USFWS Engineers and TransCanada) that resulted in the observed increase in passage counts, effective in 2012.

Bellows Falls Fish Ladder was operated in 2019 and passed three shad versus the 733 counted for 2018 at this facility. This project's ladder was, by agreement, previously triggered on Atlantic Salmon upstream passage needs, so its period of operation was often limited/restricted in the past. Beginning in 2013, TransCanada now Great River Hydro, agreed to open this ladder based on a trigger of 100 Sea Lamprey passed at Vernon Dam following a request from CRASC, providing an opportunity for upstream passage/habitat access.

Connecticut DEEP continued its long-term juvenile Alosine Seine Survey, sampling seven locations starting a few kilometers downstream of Holyoke Dam to Essex, CT from July through October in 2019. The 2019 assessment yielded a modest level of shad production shown in figure 6 relative to the data time-series. Note that 2018 was the time series record high for the shad JI. The Blueback Herring juvenile index value was also modest in 2019 and is shown relative to the data time series (Figure 7).

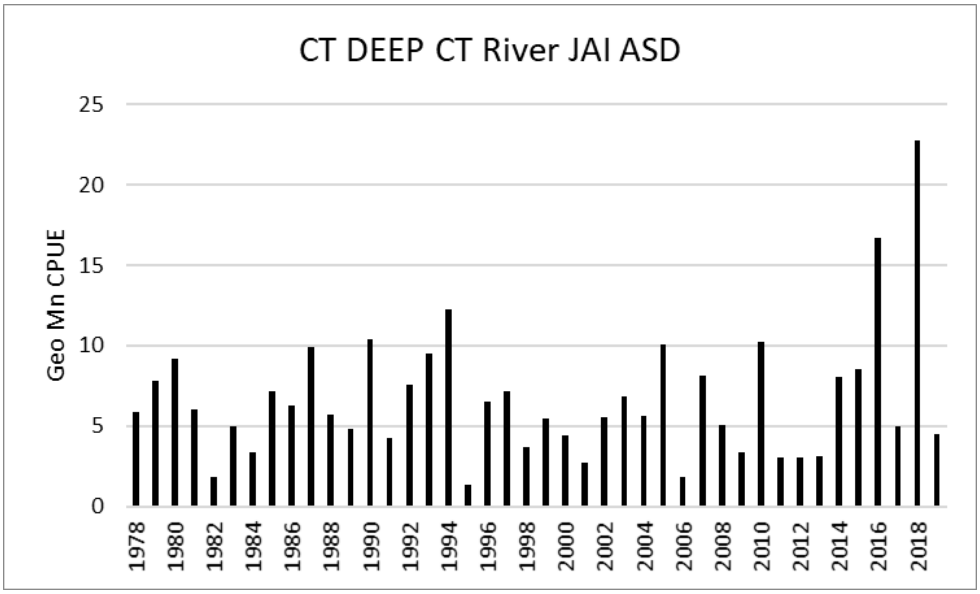


Figure 6. CTDEEP Juvenile Alosine Seine Survey, American Shad annual geometric mean catch, figure provided by Jacque Benway CTDEEP.

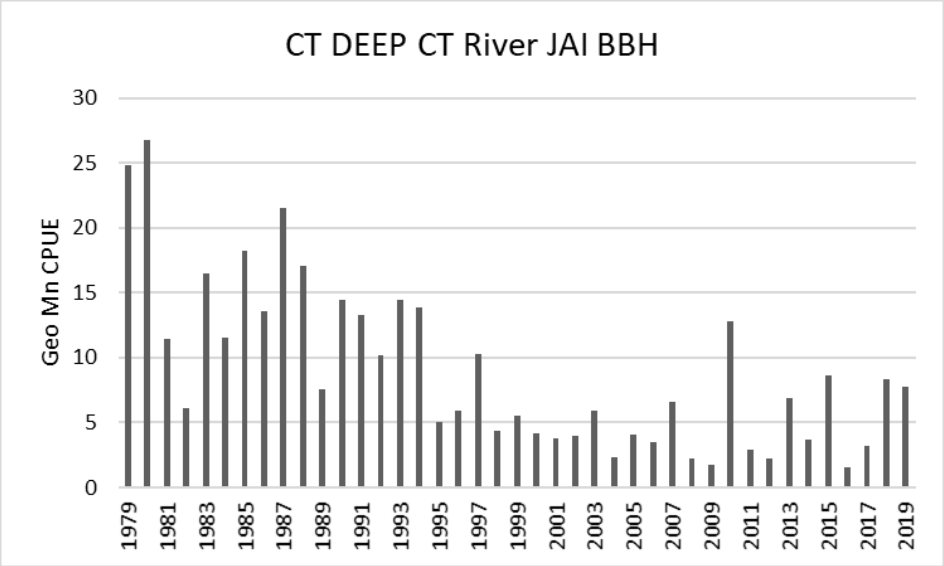


Figure 7. CTDEEP Juvenile Alosine Seine Survey, Blueback Herring annual geometric mean catch, figure provided by Jacque Benway CTDEEP.

The CTDEEP (Jacque Benway) provided an update on the commercial net fishery for American Shad that shows the landings, effort, and catch/per effort values tracked by CTDEEP (Figure 8). It is clear that both the trips and landings have been on a decline over the time series, with the most recent years illustrating new all-time low levels.

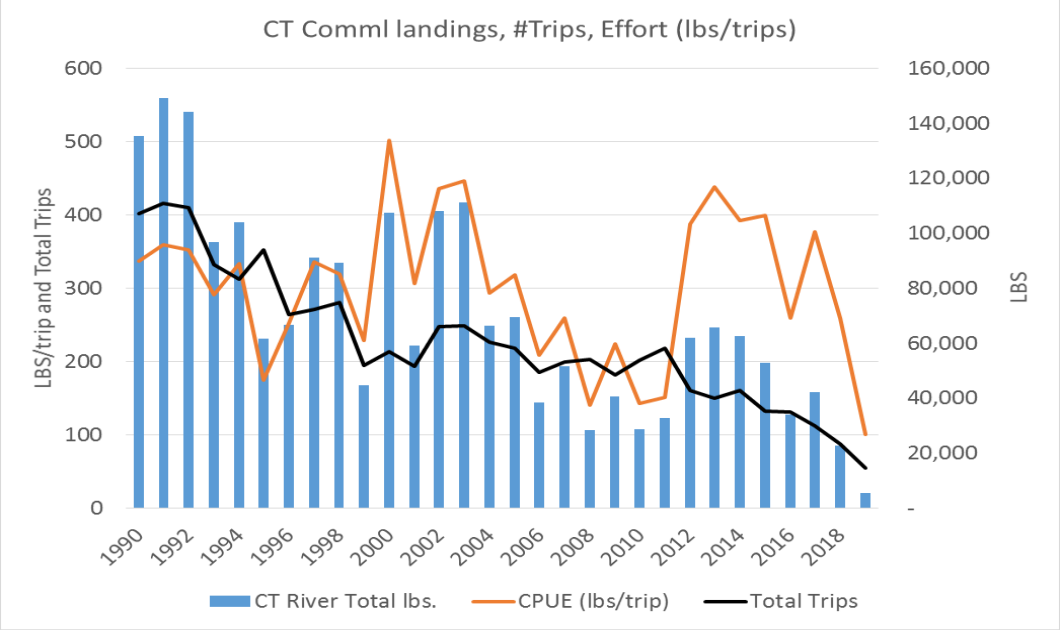


Figure 8. Figure from CT DEEP Marine Fisheries showing reported annual commercial shad landings with trip and catch per unit effort (lbs./trip), figure provided by Jacque Benway CTDEEP.

Shortnose Sturgeon – A total of 20 Shortnose Sturgeon (SNS) were trapped at Holyoke Fish Lift from lift operations in 2019, with the first fish captured on 6/12/19 (Figure 9). The operational period to pass sturgeon extended until 11/13/19, when water temperatures had decreased to 4C. This is the fourth year of operations of the modified spillway lift entrance design to pass sturgeon, with annual counts tracking closely among the first 3 years, decreasing notably in 2019 (Figure 9). There were no noted changes in the operation or facility in 2019. The timing of sturgeon movement in 2019 was within the expected range for timing (Figure 10). The size of the fish (with some exceptions) were notable smaller than in recent years. Analyses of those data and other data are not complete at this time.

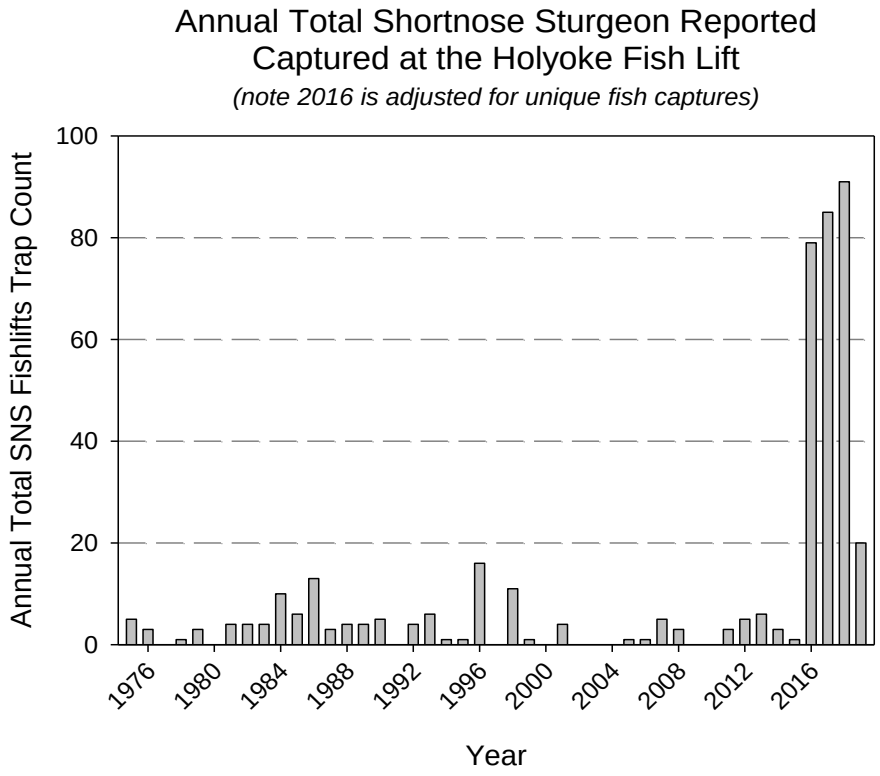


Figure 9. Annual total counts of Shortnose Sturgeon trapped at Holyoke Fish Lift 1975-2019.

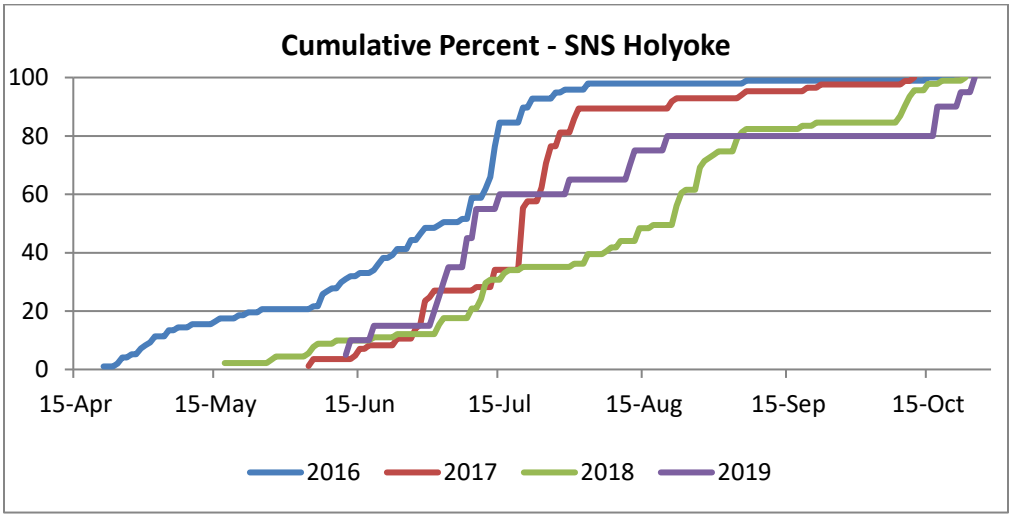


Figure 10. Annual cumulative frequency plots for captured Shortnose Sturgeon at Holyoke Fish Lift in relation to time of year (annual data from 2016-2019).

Blueback Herring - A total of 5,052 Blueback Herring were counted at the Holyoke Fish Lift in 2019 an increase from the 1,060 counted in 2018 (Figure 4). It is the highest passage count since 2001. The 2019 passage count is less than 2% of the lower bound annual passage target (300,000 fish) at Holyoke Dam from the CRASC River Herring Plan. The CTR FWCO office had conducted annual Blueback Herring transfers for the period 2013-2016 (inclusive) to habitat above Holyoke Dam that totaled 10,380 fish. It was hoped that these transfers would increase adult returns upstream of Holyoke. There is no way of determining whether the 2019 passed fish had any relationship to those efforts and is confounded by the "high" relative abundance value we determined for 2019 (a value believed to be biased low due to high flows).

The CRASC River Herring Management Plan identifies an annual passage goal of 300,000-500,000 at the Holyoke Fish Lift. That goal had been attained and exceeded up to the early 1990s, as population declines were also being observed along much of the East Coast. The earlier reported population assessment data must be considered in the context of the magnitude of this decline reflected in Holyoke counts.

Sea Lamprey - A total of 20,479 Sea Lamprey were observed from first barrier fishways or estimated by nest counts (CTDEEP nest counts) returning to the Connecticut River basin in 2019. This is an increase from the 2018 counts, driven primarily by the Holyoke Fish Lift, but observed among all counts. Holyoke passed 18,347 Sea Lamprey in 2019 compared to 10,238 in 2018 (Figure 4). A total of 3,700 Sea Lamprey subsequently passed upstream of Turners Falls Dam (through Gatehouse Ladder), or 20% of the number passed at Holyoke (a similar rate of decrease observed with shad from the prior year). A total of 2,330 Sea Lamprey passed upstream of Vernon Dam (or 63% of Gatehouse Ladder total) with 148 lamprey passed upstream of Bellows Falls Dam. In the lower river basin, 946 Sea Lamprey passed at Rainbow Dam versus 896 in 2018. A total of 495 Sea Lamprey passed upstream of the West Springfield fishway, compared to 138 in 2018.

Striped Bass - A total of 207 Striped Bass were counted passing at the Holyoke Fish Lift in 2019 and continues a decline in observed passage numbers for these smaller size fish.

American Eel – The American Eel passage count at Holyoke Dam, which used three specially designed ramp/traps in different project locations (tailrace fish lift entrance, upper stilling basin, and S. Hadley shore of bypass reach), totaled 27,505, in 2019. This is a substantial increase from the 8,562 eels counted in 2018 (Figure 11). Eel ramps were deployed in May and June and operated through November 2019, with varied limited out-of-service periods. Eel ramp/traps are not checked on weekends after July 15, same as the upstream lift operations noted with SNS. The Holyoke Gas and Electric Report on American Eel passage will be available in the winter of 2020 and will compare catch rates among the trap locations and provide details on other statistics. American eels captured in these ramp/traps are relatively small primarily ranging between 10-20 cm in total length.

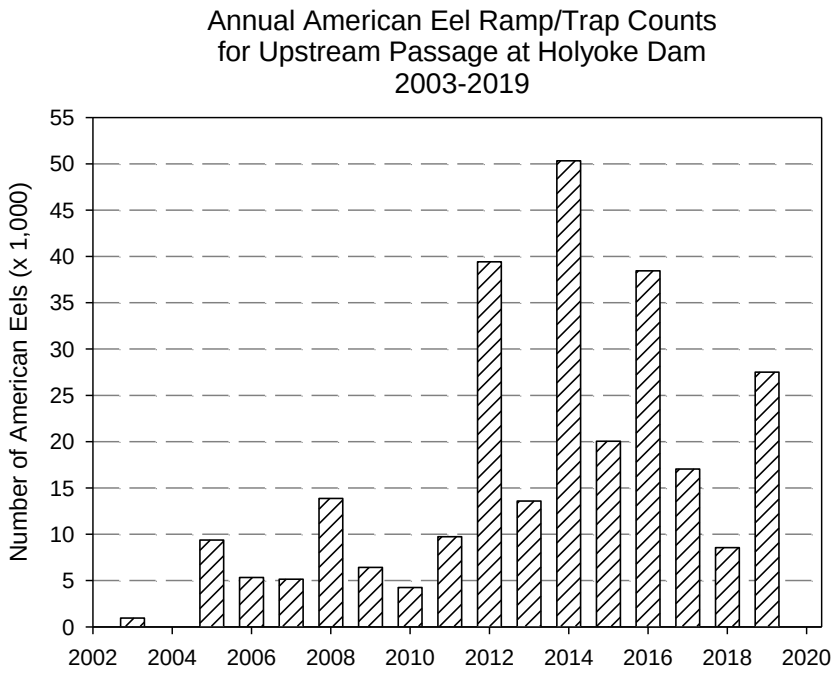


Figure 7. Annual American Eel ramp/trap counts reported by Holyoke Gas and Electric, at Holyoke Dam, for the period 2003-2019.

Atlantic Salmon – In 2019 three sea-run adult Atlantic Salmon were documented returning to the basin at the Holyoke Fish Lift. In 2018 two sea-run adult Atlantic Salmon were documented as returned to the Connecticut River basin. Historically adult returns are dominated by four year old fish (age-2 smolt and two sea winter assignments). The three fish passed in 2019 were sampled for scales (aging) and allowed to pass at Holyoke. One of the three (a grilse) was documented passing the Turners Falls Spillway ladder and Gatehouse ladder.

Gizzard Shad - A total of 320 Gizzard Shad were counted at the Holyoke Fish Lift in 2019, an increase from the 70 observed in 2018.

Appendix A. An example of the Fishway Count Report produced by CTR FWCO for distribution and posted on the office web site. Often a second page include field pictures or other data.

2019 Connecticut River Basin Fishway Passage Counts

Report Date: 7/24/2019

This report is compiled by the U.S. Fish and Wildlife Service, CT River Fish and Wildlife Conservation Office using fishway count data provided by several agencies as well as power companies and is dependent in many cases on the review of video counts, that have an associated time lag for updates. Please visit http://www.fws.gov/r5crc for more information.

Fishway, River - *State*	*Data as of:*	American Shad	Alewife	Blueback Herring	Atlantic Salmon	American Eel	Sea Lamprey	Striped Bass	Gizzard Shad	Shortnose Sturgeon	Other/ comment
Mary Steube, Mill-*CT*	final		11,232								
Moulson Pond, Eightmile-*CT*	final	4	13	51			5				
Leesville, Salmon-*CT*	operating						674				based on nest survey
StanChem, Mattabesset-*CT*	final	2	62	5			12		46		
Rainbow, Farmington-*CT*	7/3	276	1				946				
W. Springfield, Westfield-*MA*	final	4,064		5			495				closed
Holyoke, Connecticut-*MA*	7/22	314,361		5,052	2	632	18,347	207	320	12	
Easthampton, Manhan-*MA*	6/19						77				55 White Suckers
**Turners Falls, Gatehouse Connecticut-*MA*	7/7	22,575		1			3,683				3 fishways closed on 7/9
Vernon, Connecticut-*VT*	6/30	12,848				691	2,256				
Bellows Falls, Connecticut-*VT*	7/7	4					152				
Wilder, Connecticut-*VT*	not run										
*Total to basin, only **first** barrier counts*		318,707	11,308	5,113	2		20,479		366	12	
Last year totals		281,329	7,322	1,078	2	8,562[A]	11,548	268	96	91	

*** Spillway Fish Ladder - at the dam (thru 6/6) 8,762 shad; Cabot Station Ladder - base of canal (thru 6/7) 18,367 shad. Note that at Turners Falls Project (Dam/Canal) fish must use one of these two fishways first before having the opportunity to pass the final required ladder (Gatehouse).*

A - total collected from 3 eel ramp/traps at Holyoke in 2018, that operate through October

The Holyoke Fish Lift concluded its "spring" season schedule on 7/15, with very few American Shad observed in the final week. The operations at the facility are now focused on passing Shortnose Sturgeon and juvenile American Eel. Both water temperatures and flows are within expected ranges for this time of year. The Connecticut River Atlantic Samon Commission's Technnical Committee meeting was held on 7/16, covering a fairly extensive agenda of topics. If anyone is interested in handouts (e.g. my update items) from that meeting please contact me. Note that the Commission meeting is scheduled for 8/8 and if you are not on the email notification list for CRASC but wish to be, please email me.

Appendix B. History of the Anadromous Fish Program

Native diadromous fishes (diadromy includes anadromous and catadromous fishes, with American Eel being the only catadromous species in this basin) were once abundant in the Connecticut River basin excluded from habitat only by natural barriers and their physiological limitations. Atlantic Salmon ascended the main stem Connecticut River to Beechers Falls, VT, nearly 400 miles upriver from its outlet at Long Island Sound. American Eel have been documented even farther upstream in the basin by early New Hampshire Fish Game Department studies in Pittsburgh, New Hampshire. No fishery management or scientific information exists that provides an accurate technical description of the pre-colonial diadromous fish populations. However, historical accounts of the region are filled with references to large American Shad, river herring and Atlantic Salmon runs that were known to have been an important food source in the spring for the native people and early European settlers. As colonization by Europeans and the development of waterpower sites expanded throughout the basin, anadromous fish populations notably declined. A major cause of the declines or loss of runs was from the construction of dams that blocked fish migrations from reaching their spawning habitat (Figure 1). Tributaries were more easily dammed and so elimination of these species progressed rapidly in these areas first, with settlement and use of early waterpower for mills. The first dam across the main stem Connecticut River was constructed as early as 1798, for barge/boat movement, near the present site of Turners Falls, Massachusetts. This dam blocked returning American Shad, river herring, Atlantic Salmon and Sea Lamprey from access to spawning and nursery habitat in the northern and central portion of the river basin. As a result, those species simply disappeared from areas of the basin in both New Hampshire and Vermont, not to be seen again for nearly 200 years.

An interagency state/federal program to restore Atlantic Salmon to the Connecticut River based on the stocking of fry hatched from eggs taken from Penobscot River Atlantic Salmon was initiated in the 1860s, decades after the construction of the Holyoke Dam, MA. Although the effort resulted in the return of hundreds of adult salmon for several years in the 1870s and 1880s, the program eventually failed due to both uncontrolled harvest of fish in Connecticut waters and the failure to construct effective fish passage at dams in Massachusetts. Concurrent with the salmon restoration effort were the state's American Shad culture and stocking efforts to enhance reduced runs of this valued species. Work to restore and enhance these two species was conducted through developing fish culture techniques that were gaining popularity as an approach to achieve fishery management goals.

Although interest continued in restoring Atlantic Salmon to the basin, no action was taken for many decades due to the lack of funds and the lack of effective fish passage technology (an early design fish ladder had been installed at Holyoke Dam). The condition of the river environment continued to deteriorate in response to widespread pollution and dam construction through the early to mid-1900s. By the 1960s, some tributary dams were breached and pollution abatement programs were initiated. Long-term cooperative restoration programs became feasible with the passage of the federal Anadromous Fish Conservation Act of 1965 (P.L. 89-304) which made funds available for interstate fish restoration programs. The combined effects of these events set the stage for coordinated anadromous species restoration. In 1967 the four basin states and USFWS, (National Marine Fisheries Service later created from the USFWS in 1970) signed a

statement of intent to restore anadromous fishes including American Shad, Atlantic Salmon, and river herring to the Connecticut River. Atlantic Salmon were a focus due to its appeal for recreational angling opportunities by the resource agencies. Early salmon stockings were initially comprised of two-year old smolts of Canadian origin reared in federal trout hatcheries that had recently been converted to salmon production. The term smolt defines a salmon life-stage when the transitional migration from freshwater to the marine environment occurs, typically in the months of April and May. The first adult salmon return from these hatchery smolt releases was documented in 1974.

Early in the Atlantic Salmon Program, the management emphasis was placed on stocking smolts with the USFWS building a salmon hatchery in Bethel, Vermont, and CTDEEP and MADFW converting trout hatcheries for salmon production. Production of stream-reared smolts, from juvenile stockings was combined with smolts produced in hatcheries to increase smolt emigration from the river. A major effort was begun in 1987 to stock fry into appropriate habitat in the basin, based upon in-river research results.

Beginning in 1994, the Program utilized only "Connecticut River" fish, with no introductions of genetic material from outside the basin. Genetic monitoring had demonstrated the development of some unique genetic characteristics (alleles) that distinguish the Connecticut River population from other populations at that scale. The use of conservation genetics enabled the Program to maintain a genetically healthy population to maximize genetic diversity and reduce risks from genetic issues.

Adult Salmon returns per 10,000 stocked fry declined dramatically from what had been documented from 1979 through 1994, when this rate averaged 0.71 (high of 1.6). For the period 1995 through 2008, the mean adult/10,000 fry stocked was 0.11 (refer to U.S. Atlantic Salmon Assessment Committee Report 27 – 2014 Activities (http://www.nefsc.noaa.gov/USASAC/Reports/). This later period is when the program shifted to fry stocking as the primary restoration strategy, coinciding with this unexpected decline in fry return rates (due to marine survival rate decreases). This situation translated to a sustained reduction approximately 1/6 of what had been observed for this rate (< 1994) even as issues of safe downstream passage of smolts at hydropower facilities and ocean fishery closures were completed. Studies over time have shown shifts in salmon marine prey species abundance and distributions, shifts in predator assemblages, and shifts in marine habitat area use are likely contributing factors that can be related to climate change.

The severe damage to the White River National Fish Hatchery (WRNFH) in fall of 2011, from a flood event, severely impacted the Salmon Program as it maintained a high proportion of the domestic broodstock and subsequently annual egg and fry production for all the states. WRNFH had been producing approximately 65% of the fry for the Program in the preceding 10 years. The loss of this facility, in conjunction with ongoing reviews of the best science and information related to restoration efforts, and emerging USFWS Northeast Region fisheries issues and priorities, led the USFWS to announce its decision to conclude fish culture activities for the Connecticut River Atlantic Salmon Program. That announcement was made in public at the July 2012 Connecticut River Atlantic Salmon Commission meeting. Subsequently, in the fall of 2012, the Commonwealth of Massachusetts decided it would no longer culture salmon at its Roger Reed State Hatchery. The last spawning of domestic salmon broodstock occurred at that

facility in 2012, with all fry and remaining Connecticut River salmon of various ages stocked out in 2013. The State of New Hampshire had concluded the restoration effort with a last stocking in 2012 while the final stocking in Vermont was in 2013.

The State of Connecticut currently operates a "Salmon Legacy Program," which is not a restoration program but serves other defined purposes. The goal of Connecticut's program is to maintain Atlantic Salmon in select watersheds, maintain existing genetics of the Connecticut River salmon, provide fish for their state broodstock fishery program (outside of the Connecticut River basin), and support educational programs such as the school egg/fry rearing program.

Action to provide upstream fish passage on the Connecticut River main stem in the mid-1900s occurred in 1955, when a rudimentary fish lift was constructed at Holyoke Dam to pass American Shad and river herring, that relied on humans pushing them in wheeled buckets for release upstream of the dam. At that time, and for approximately three decades after, the Enfield Dam remained a partial barrier, even though laddered; it eventually disintegrated completely in the late 1980s. The Holyoke Dam facility was expanded in 1976 when substantial upstream passage modifications occurred, with a new second lift installed in the spillway (or at the base of the dam, as opposed to the existing "tailrace" lift entrance where the turbines release). Although not studied, upstream passage efficiency appeared to improve greatly with corresponding increases in annual fish counts for species like American Shad and Blueback Herring (Figure 4). Other fishways built at dams on the main stem river and tributaries allowed returning Atlantic Salmon, American Shad, river herring, American Eel, and Sea Lamprey access into select portions of the basin (with varying degrees of fishway effectiveness) targeted for restoration. Major issues with several different fishways have been apparent relative to ineffectiveness at passing American Shad, river herring, American Eel (downstream) and Shortnose Sturgeon. These issues have been dealt with on a case-by-case basis, with varied degrees, of success. However, with the Federal Energy Regulatory Commission's five main stem project relicensing currently underway (2013…), opportunities for improvements for fish passage are anticipated along with plans to address other problem passage sites in the near future (e.g., Rainbow Fishway on the Farmington River).

Upstream passage at Turners Falls Dam (Massachusetts) fishways (first operational in 1980) have been studied and modified for decades and is one of the projects in the FERC relicensing process at this time. Passage issues relative to American Shad are best explained by the fact that no ladders of the size required on the main stem had been designed for that species as the cooperative restoration effort took this management need on in the 1970s. The USFWS relied on the best information (no specific studies available) at the time that suggested West Coast fish ladders on the Columbia River were effective at passing introduced American Shad. This led to the adoption of these designs, downsized considerably from the Columbia River, for use on the main stem Connecticut River dams. The USFWS worked with the power companies in the design and construction, to develop operating parameters for flow, velocities, and turbulence measures. However, the downscaling created some unforeseen challenges in hydraulics for these species that the agencies, researchers (USGS CAFRC), and power company consultants have worked on resolving over the years with increasing knowledge.

Following on the Turners Falls ladders completions, the Vernon Dam (Vermont) fish ladder became operational in 1981 with Bellows Falls and Wilder dam fish ladders in the subsequent years. As the number of salmon fry stocked in the basin increased during the late 1980s, concern grew for the potential negative effects of hydroelectric turbines or other passage routes on

outmigrating smolts, as well as juvenile and post spawn adult American Shad. Efforts to provide safe and effective downstream fish passage on both main stem and tributary projects were initiated in the 1980s. In 1990, a Memorandum Of Agreement (MOA) were signed with two major utility companies that operated hydroelectric facilities at six main stem projects that established time frames for downstream fish passage construction. The Holyoke Dam and Hadley Falls Power Station is a good example of a very recent large-scale fish passage improvement project, designed specifically to address; downstream passage and protection of adult American Eel and Shortnose Sturgeon as well as upstream passage of Shortnose Sturgeon and other anadromous species that became operational in 2016, using new engineering approaches.

The state and federal agencies continue to work in close cooperation with many partners to address fish management, protection, enhancement, and restoration topics for both populations and habitats. This work is important for the ecological, recreational, and commercial benefits, derived from healthy native fish populations and the aquatic habitats they require. Currently, ongoing fisheries work includes continuing efforts to increase both diadromous species abundance levels and distributions (particularly upper basin and in tributaries) as well as stock structure characteristics (e.g., multiple age classes) to support population resilience and health (as characterized by status). The current FERC relicensing process for the five main stem facilities is important in this regard relative to the 50-year length of these federal licenses and the opportunity to seek conditions and measures that protect the public's fishery resources now and for future generations. The CRASC and its predecessor, the Connecticut River Policy Committee, have provided and continue to provide, a critical coordinated fishery leadership role from policy setting to project implementation, resulting in many positive outcomes not commonly observed in other large East Coast river basins.