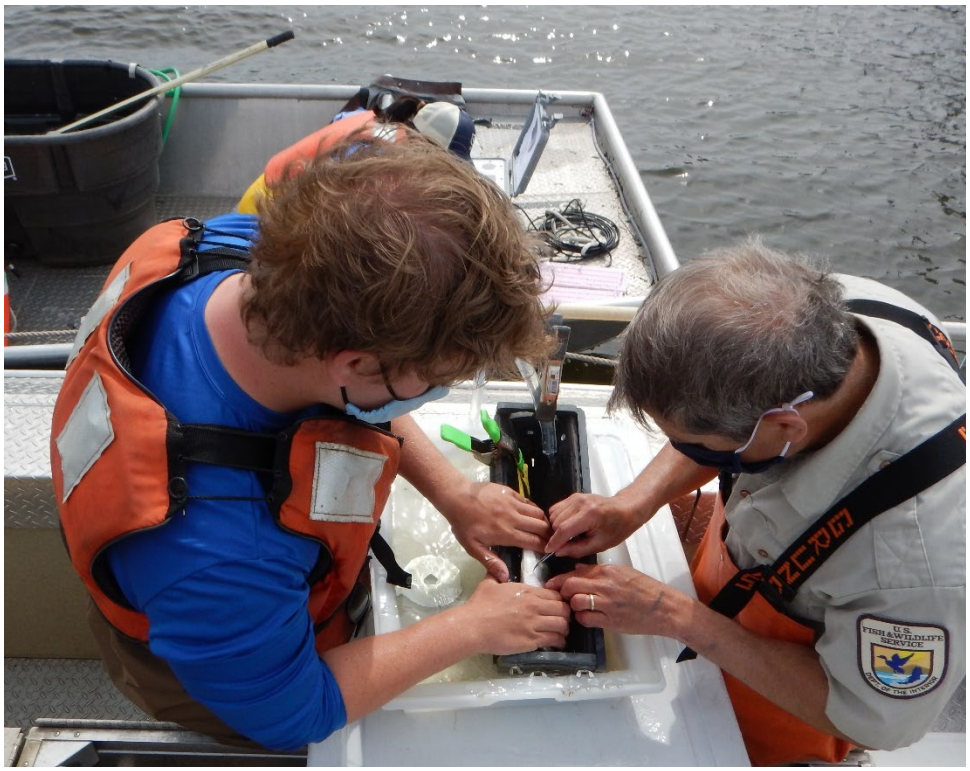
CONNECTICUT RIVER BASIN ANADROMOUS FISH RESTORATION: Coordination and Technical Assistance F-100-R-38



Annual Progress Report
October 1, 2020 - September 30, 2021

U.S. Fish and Wildlife Service
Connecticut River Fish and Wildlife Conservation Office
Kenneth Sprankle, Project Leader
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Executive Summary

Federal Aid Project # F-100-R-38

States: Connecticut, Massachusetts, New Hampshire, and Vermont

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

Period Covered: October 1, 2020 - September 30, 2021

This annual report provides an opportunity to organize and document, to varying degrees, 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.

Cover photo – Surgical implant of acoustic tag into a Blueback Herring in April of 2021 for the migration and movement study done cooperatively with the United States Geological Survey's. Conte Anadromous Fish Research Center.

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 and coordinated two Connecticut River Atlantic Salmon Commission (CRASC) meetings and two Technical Committee meetings.
- Coordinated the fourth and fifth seasons (fall 2020 and 2021) of the juvenile alosine survey with state agencies cooperators and other partners for the upper basin.
- Assisted in organizing a meeting of the Holyoke Cooperative Consultation Team to address Holyoke Project fish passage items among members.
- Provided annual upstream and downstream fishway operations letters (for CRASC) to

hydropower owner/operators and the Federal Energy Regulatory Commission (FERC).
- Coordinated with main stem power companies and state agency partners to ensure fish passage facilities were operated as planned in 2021.
- Coordinated with CRASC Technical Committee members to update the ASMFC's Connecticut River American Shad Habitat Plan.

Technical Assistance

- Continued to work with state and federal agency partners on development of Section 18 Fish Passage documents and planning for the FirstLight Turners Falls and Northfield Mountain Pumped Storage Project over the course of the report year.
- Worked with New Hampshire Fish and Game (NHFG) and National Oceanic and Atmospheric Administration (NOAA) Fisheries to complete an update of the Ashuelot River Migratory Fish Restoration Plan and submitted that to FERC as an update to the existing Comprehensive Management Plan.
- Worked with an interagency team to develop study requests for the Fiske Mill Hydro Project, whose federal license is expiring (first upstream dam on the Ashuelot River, NH).
- As the USFWS member to the ASMFC Shad and River Herring Technical Committee (TC) worked on a variety of TC activities over the course of the report year. Served as a subcommittee lead on a fish passage recommendation memorandum based on the 2020 ASMFC Benchmark Stock Assessment for American Shad.
- Worked to develop memos, work group tasks and products to address ASMFC Shad and River Herring Board requests to further develop recommendations to better direct necessary action on American Shad and fish passage measure on the East Coast.
- Participated in interagency/stakeholder group as well as power company related confidential agreement work on facility operations of Great River Hydro (GRH) main stem projects. The product of this was reflected in the December 2020 Amended Final Application of Great River Hydro.
- Served as the USFWS member to the NOAA Fisheries River Herring Technical Expert Group.
- Served as the USFWS representative to the NOAA River Herring Habitat Conservation Plan's Steering Committee. Steering Committee work is ongoing as the report product is developed for 2022.
- Over report period, participated in interagency and GRH confidential agreement discussions dealing with fish passage measures. That work remains ongoing.
- Participated as team member in a Federal Agency work group (USFWS and NOAA) on FirstLight fish passage prescription measures and related items.
- Completed the Annual Sport Fish Restoration Grant Report for FY20, in January 2021 and posted on CTRFWCO web site.
- As Chair of CRASC TC River Herring Subcommittee, provided updates and coordinated with partners for the 2021 Connecticut River Blueback Herring Migration and Movement Study done in partnership with the USGS Conte Research Center (Dr. Ted Castro-Santos). The CTRFWCO and USGS Conte designed and implemented the study but had important technical and logistical support from CTDEEP.
- The CTRFWCO completed a total of 9 juvenile shad assessment sample dates in the Bellows Falls to Vernon Dam reach and the Vernon to Turners Falls Dam reach, concluding on

October 28, 2020. A total of 141 juvenile shad were sampled in 45 standardized sample runs that were from selected from random stratified zones and cell. This occurred under Covid rules, so only one netter vs. two were used and overall sample effort (dates) was about 50% of previous years.

- Conducted the annual adult river herring assessment in the lower Connecticut River basin for the eight year (2020 canceled from Covid). Sampling occurred on 24 dates from April 5 through June 16, 2021. A total of 1,662 Blueback Herring were captured and processed on the boat with 127 Alewife also captured and processed. A portion of field processed fish were retained for laboratory processing (otoliths, scales, gonads, tissue), results will be covered later.
- Data from spring 2021 Adult River Herring Population Assessment Program were entered into the Access database and spreadsheets to compare many metrics that are objectives of this program (catch rate, size, gonad status). Otolith aging was initiated in the fall of 2021, results covered later.
- Scale samples from the Blueback Herring (n = 929) and Alewife (n = 114) that were laboratory processed, were cleaned, and slide mounted. All scale samples were examined by projector for spawning history by two readers independently, analyses covered later. Consensus determinations were made for those samples not in agreement (~25%).
- Provided program information and requested data (e.g., fish counts) to cooperators, researchers, power companies, and the public.
- Administered grant/program agreements for three Student Conservation Association interns that worked full time from April 1st through August 27th of 2021.
- Completed tissue sampling provided for USFWS Fish Health examination of Holyoke American Shad.
- Conducted the cooperative Juvenile Alosine Production Assessment with primary partner MA Division of Fisheries and Wildlife starting in the last week of August 2021.
- Standard data from the Juvenile Survey were recorded, entered, and summarized during the season and shared with MADFW.

Cooperative Research

- Served as USFWS project officer and cooperator for the U. S. Geologic Survey University of Massachusetts Cooperative Fish and Wildlife Research Unit and Conte Fish Research Laboratory (CAFRC) study, "Environmental Factors Controlling Juvenile River Herring Productivity and Emigration (2019-2022)", partially supported by the USFWS Science Support Program.
- A substantial amount of effort was put into preparation for the 2021 Blueback Herring Acoustic Study in the winter of 2021. Mooring receiver set ups, net gear, live car cages and receiver setups and other boat set up for deployments (two boats used) and for later capture and tagging were all completed.
- In the first two weeks of March a total of 32 acoustic receivers were deployed from Old Lyme Connecticut to Holyoke Massachusetts, in the main stem, select tributaries and cove habitats.
- Acoustic tagging trials with dead and live fish were completed with assistance from Dr. Alex Haro (USGS), including tagging equipment and related gear designed by Alex.
- Short set, live tended, drift gill nets were fished in the main stem river, Old Lyme

Connecticut from April 6 through May 24, 2021. A total of 155 acoustic tags were surgically implanted into Blueback Herring, more detail will follow later in the report.

- A total of 31 or 32 receivers were recovered by the end of August 2021. Data downloads provided substantial data on released tagged fish that is under review.

Outreach

- In fall of 2020 completed a field sampling interview video organized by the Connecticut River Conservancy and later participated in the live stream of that video with World Fish Migration Event on October 28, 2020.
- In February did a podcast interview with the Montague Reporter covering migratory fish restoration and fish passage.
- Produced the CT River Basin Fishway Counts report and distributed weekly in spring season (less frequently later in year) electronically and posted updates on the Office web site and maintained databases (Appendix A).
- Worked with USFWS External Affairs and partners to develop a CRASC Outreach news item that was posted on the USFWS Regional Web site in July that focused on the topic of fish passage.

Acknowledgements

In the late fall of 2020 Stephen Gephard retired from the CT DEEP as its Supervisory Biologist of both the Diadromous Fish and Habitat Program after over 30 years of service to that agency. His career also included many other important roles including leadership at many levels from the Connecticut River basin (CRASC), New England and Northeast regional teams and committees, the Atlantic Coast (ASMFC) and internationally for Atlantic Salmon conservation, including representing the United States government. His career had significant positive impacts in restoring both habitat and access for fishes, active population restoration measures and their development, outreach, and engagement with partners and public, planning, evaluation, course trainings/teaching, and research in many areas with academics and state and federal researchers. No less important was his training and mentoring of a lengthy list of young seasonal staff he managed over this time at CTDEEP that have gone on to careers as state and federal fisheries biologists (that include myself).

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 population assessment program and the 2021 acoustic tagging study. Phil Herzig (USFWS) was exceptionally helpful in the preparing equipment and boats/gear for the acoustic tagging study and in assisting in deploying the receivers in early March.

The three Student Conservation Interns that worked April through August, performed exceptionally well in all activities they were involved with supporting. Carolyn Merrimam, Bill Storm, and Doug Rouse made significant contributions to many aspects of the acoustic tag study's implementation, the river herring population assessment program and many facets of those projects and other work, that would not have been possible without their hard work, skills, and abilities.

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 areas) over the course of the year.

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

State fishery agencies -

- Connecticut: Kevin Job, Tim Wildman, Jacque Roberts, Justin Davis
- Massachusetts: Caleb Slater, Steven Mattocks, Brian Keleher and Ben Gahagan
- New Hampshire: Matt Carpenter and Gregg Comstock
- Vermont: Lael Will (and her seasonal technicians), Hannah Harris, Jeff Crocker, Eric Davis

Federal agencies –

- USFWS: Melissa Grader, Phil Herzig, Brett Towler, Jessica Pica, Dave Sagan, Andy French, David Perkins, and Tim Warren
- NOAA Fisheries: Bill McDavitt, Sean McDermott, Bjorn Lake, and Julie Crocker
- USGS Conte Lab: Ted Castro-Santos, Alex Haro, 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 develop and 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 eight subcommittees, with specific areas of responsibility (American Shad, River Herring, Atlantic Salmon, American Eel, Sturgeon, Sea Lamprey, Fish Passage, and Habitat). 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 the USFWS Ecological Services Division on Federal Power Act with select FERC projects, 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. The Coordinator serves as the USFWS representative to the Atlantic States Marine Fisheries Commission's Shad and River Herring Technical Committee and on other committees as needed.

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 2021, there were three documented adult Atlantic Salmon returns to the basin, all at the Rainbow Dam Fishway (Farmington River). The CTDEEP continues fry stocking with its Atlantic Salmon Legacy Program. In 2021, a total of 33,585 salmon fry were stocked in the West Branch of the Farmington River in May. Fry were reared at the Kensington State Hatchery that had chiller issues impacting eggs and fry development. This effort maintains a presence of this species in the basin and serves many other CTDEEP objectives including popular outreach and school education programs.

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 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 (and its subcommittees) meets as frequently as needed. This report period, the Commission met on December 2, 2020 and on February 9, 2021. The CRASC worked on preparing information and discussing best approaches to address the Congressional timing of the existing CRASC legislation that will expire in December 2023. A subcommittee was formed and has worked over the year to explore options and determine best approaches working with partners, FWS Regional Office and Washington Office Congressional staff, and Senator Blumenthal's Office and Senator Leahy's Office.

The Technical Committee had meetings on November 19, 2020 and June 24, 2021. The Shad Subcommittee coordinated over the year on development of an update to the ASMFC Connecticut River American Shad Habitat Plan. The Sea Lamprey Subcommittee also had meetings to plan for nest survey work in the spring. The Fish Passage Subcommittee members addressed ongoing FERC relicensing items on the main stem, tributary FERC projects, and ongoing passage activities at the Holyoke Project.

CRASC scheduled meetings (Commission and Technical) 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 or any other considerations 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 2021).

Connecticut River Atlantic Salmon Commission	
Federal	**U.S. Fish and Wildlife Service** *Wendi Weber (Secretary/Treasurer)* Regional Director, Region 5 *Lowell Whitney, alternate*
	National Marine Fisheries Service *Michael Pentony* Northeast Administrator *Christopher Boelke, alternate*
Connecticut	**Connecticut Dept. of Energy and Environmental Protection** *Rick Jacobson* Chief, Bureau of Natural Resources *Tim Wildman, alternate*
	Public Sector Representative *Tom Chrosniak*
Massachusetts	**Massachusetts Division of Fisheries and Wildlife** *Mark Tisa* Director *Todd Richards, alternate*
	Public Sector Representative *Andrew Fisk (Chair)*
New Hampshire	**New Hampshire Fish and Game Department** *Scott Mason* Executive Director *Scott Decker, alternate*
	Public Sector Representative *Donald McGinley*
Vermont	**Vermont Department of Fish and Wildlife** *Christopher Herrick* Commissioner *Eric Palmer (Vice Chair), 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** *Tim Wildman*
Massachusetts	**Massachusetts Division of Fisheries and Wildlife** *Rebecca Quinones*
	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* (Chair)

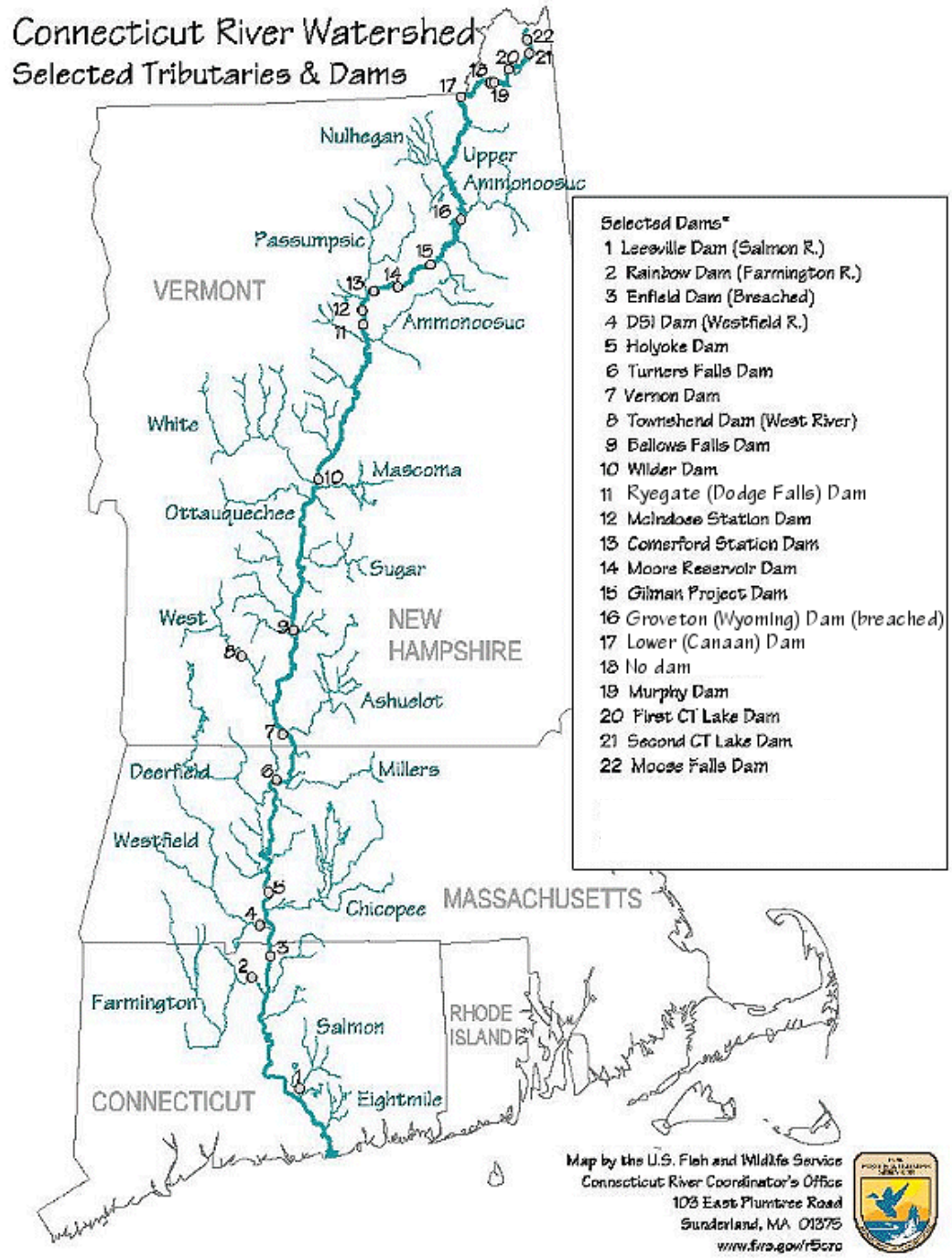


Figure 1. Connecticut River basin with major tributaries and main stem dams.

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-38, 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 $332,099 for fiscal year 2021. The Sport Fish Restoration and MADFW funds were fully drawn down to assist in partial expenses for the CTRFWCO building/grounds maintenance, 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: $348,369 **States (F-100-R):** $16,270 **FWS Federal:** $332,099

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

In 2021 the adult population assessment program for river herring was initiated by this office in early April, utilizing boat electrofishing as the primary sampling gear, for the eighth year of data. The first year of this annual program was in 2013, with 2020 work cancelled due to Covid. Study objectives of the project 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 and examine other relevant data for influence/relation on population metrics.

An additional assessment of female Blueback Herring gonad/reproductive status was conducted in collaboration with Drs. Eric Shultz (UConn), Ganias Konstantinos, and Faivos Mouchlianitis (Aristotle University of Thessaloniki, Greece) in 2019. In 2021, coordination calls were held on analyses and results of egg development stage analyses and related data that is in preparation for publication. The extraction and weight of female ovaries are now a standard laboratory processing step for a gonad somatic index.

This long-term monitoring work was developed 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 (2013-2021).

	2013	2014	2015	2016	2017	2018	2019	2021
Number of sampling dates	18	21	20	25	26	23	27	25
Total sample runs	81	124	114	145	145	147	147	118
Total electrofishing seconds	41,177	55,736	56,025	71,845	68,353	69,835	80,473	56,838
Total bluebacks captured	714	2,593	1,448	1,586	2,650	2,396	3,456	1,813
Total alewives captured	107	220	258	586	200	366	243	128
Blueback Herring otolith/scale – lab	501	655	622	730	1,192	991	1,473	929
Alewife otolith/scale - lab	103	188	165	461	190	284	217	114

There was a reduction in the number of sample days in 2021, 25 versus 27 in 2019, and a more notable decrease in sample runs between years and total electrofishing seconds. This decrease in effort is partially attributed to the Blueback Herring Acoustic Study that was in progress concurrently to the assessment program. Population sampling efforts in the Mattabesset River were essentially dropped (only one sample date in 2021) due to this situation.

In 2021, sampling was initiated on April 5 in the Mattabesset River with 11 Alewife captured. The incidences of high catch rates, leading to premature stoppage of the standard sample time, occurred on relatively few runs in 2021. These instances are only associated with Blueback Herring and never Alewife. When sampling runs encounter high catch rates (>60 fish collected) with less than 500 seconds shock time expended, the run duration is shortened, this occurred on 9 runs in 2021 versus 22 runs in 2019, 18 runs in 2018 and 16 runs in 2017 and is reflected in the aggregate catch rate summaries and comparisons (Figure 2). The annual catch rate was based on the aggregate of individual sample runs, using all sites, after Blueback Herring were determined present in the system (removes varying frequencies of zero runs when Alewife are being sampled among years). The Blueback Herring season annual aggregate relative-abundance was the second lowest value in the time series, at 2.6 fish-per-minute (standard error 0.44). In 2021, Blueback Herring were detected on April 13 which is slightly early from the more typical third week in April. Sampling concluded on June 16, 2021, like previous years, with sampling at Wethersfield Cove. Holyoke Fish Lift counted 1,242 Blueback Herring passed in 2021. There continues to be no detectable relationship between the survey CPUE and HFL counts. Data on fishway counts will follow later in this report.

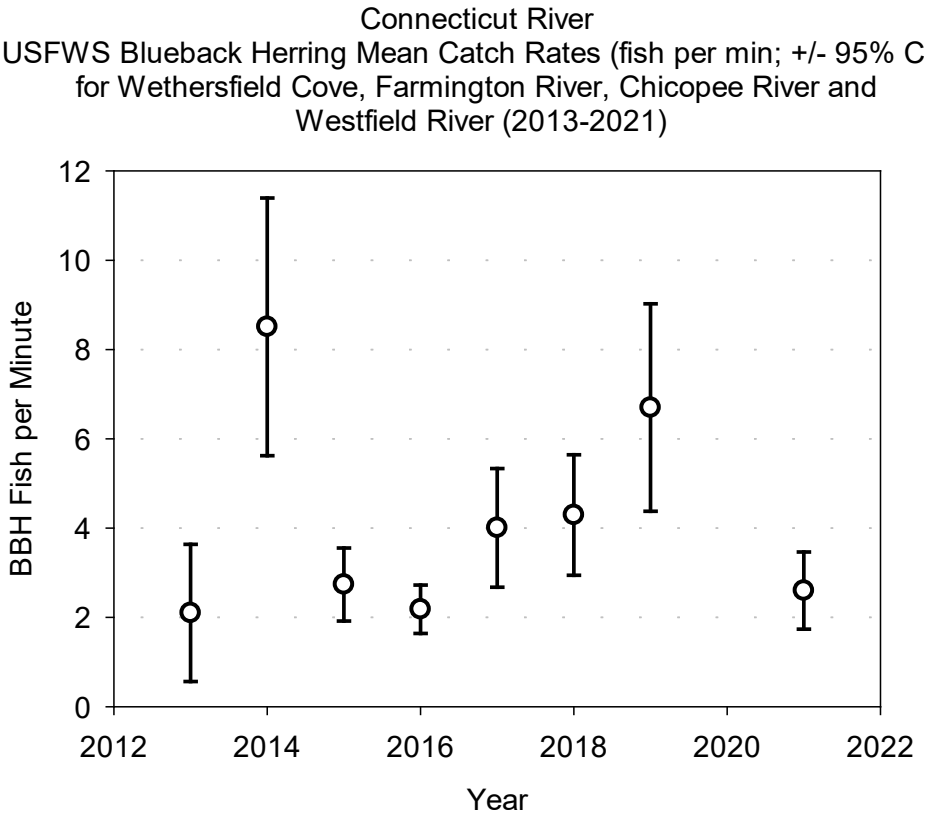


Figure 2. Annual catch-per-unit effort (fish per minute) for Blueback Herring among four standard index areas. Sample efforts prior to first documented arrivals (catches) are excluded from analyses (e.g., 108 runs vs. 118 total runs in 2021).

Blueback Herring catch rates over the sample season were highly variable, with the first occurrence of the species in sampling observed on April 13, 2021 in Wethersfield Cove and fish still present on the final sample date of June 16, 2021 at Wethersfield Cove. Catch rates for both

Wethersfield Cove and Farmington River demonstrated a brief similar decline in the second week of May, bounded by higher rates the week prior and after (Figure 3). River discharge and temperature don't appear to have any role in that episodic decline in catch rates. The 2021 acoustic tagging study may be able to provide some insight into this occurrence as the data are examined (more on this study later).

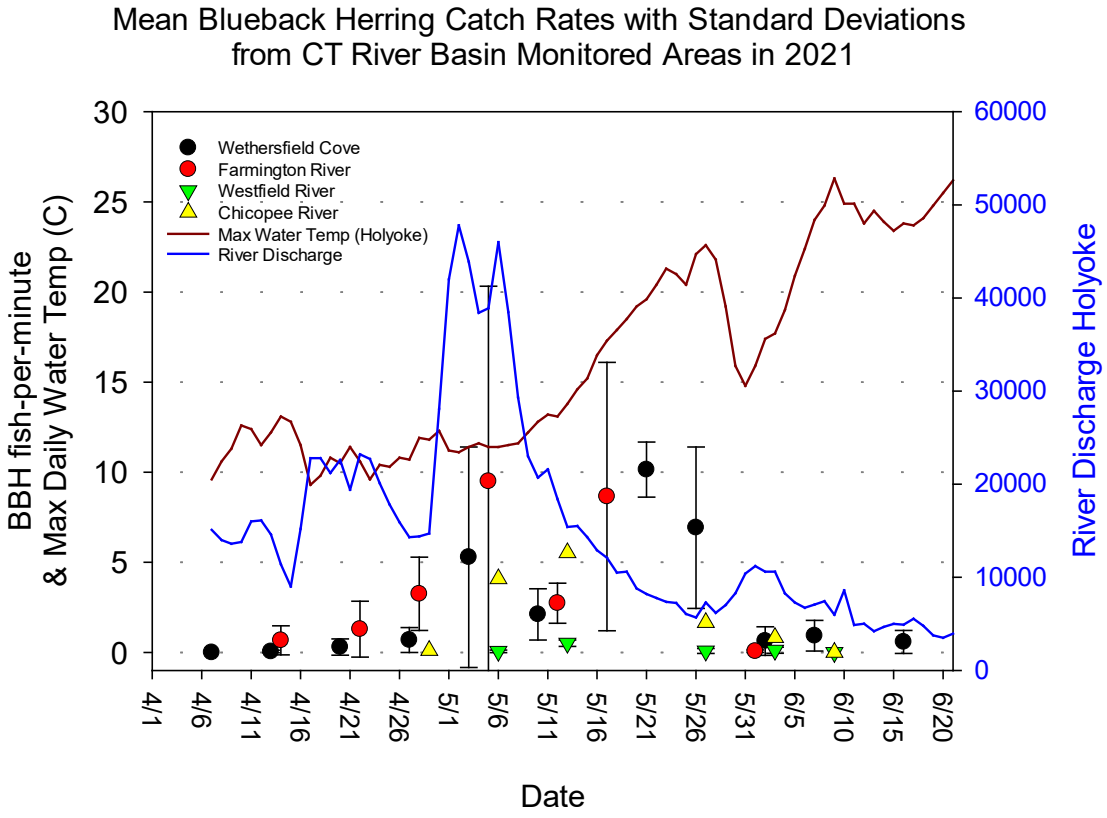


Figure 3. Adult Blueback Herring relative abundance expressed as mean fish/minute ± standard deviation, by sample area and date for 2019 season. Reported daily mean water temperature, U.S. Geological Survey, Middle Haddam, CT.

A summary of river herring mean total lengths (mm) with standard deviations are shown in Table 4, by sex, for each species, by year. The mean size of male Blueback Herring was the highest in the time series and for females it was the second highest. Male Alewife were relatively small (2nd lowest size), and females were also small in the time series (Table 4). Age structure analyses will be incorporated into later analyses (catch-at-age) and based on the previous documented high correlation with the CTDEEP Juvenile Index (four years prior), is likely a factor.

Table 4. 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 – 2021.

Year	Blueback		Alewife	
	Male Mean TL mm (± SD)	Female Mean TL mm (± SD)	Male Mean TL mm (± SD)	Female Mean TL mm (± SD)
2013	253.8 (12.1)	264.9 (12.6)	261.6 (15.8)	287.7 (16.2)
2014	253.8 (11.4)	264.9 (13.2)	266.2 (10.8)	276.1 (15.5)
2015	263.0 (10.4)	277.8 (11.7)	273.1 (11.7)	287.9 (12.4)
2016	265.2 (13.3)	281.3 (13.0)	270.7 (18.0)	286.4 (19.0)
2017	257.5 (12.7)	271.7 (14.9)	265.0 (18.3)	278.4 (21.4)
2018	256.7 (12.9)	268.4 (14.7)	269.5 (14.9)	280.0 (18.1)
2019	260.4 (9.9)	273.3 (13.4)	274.4 (11.0)	291.3 (15.0)
2021	266.5 (15.5)	279.9 (18.3)	264.5 (9.5)	276.2 (13.8)

All 2021 otolith samples for Alewife (n=114) were read for age composition. The data and analyses may be described at the site and sex level and for past years. In 2021, the smaller sample size for the year indicated a "younger" and smaller size adult run composition than in past years (Table 5). Blueback Herring otolith examination were started after the end of this report period and were not available.

Table 5. Age and size structure for laboratory processed Alewife in the Spring of 2021.

	N	Mean TL mm (± SD)	Mean Age (± SD)	Age Range
Male	67	264.3 (8.8)	3.3 (0.4)	3 - 4
Female	46	277.5 (13.4)	3.4 (0.9)	3 - 6

In addition, seasonal staff cleaned and slide mounted scale samples from the 2021 laboratory processed fish: Blueback Herring (n=929) and Alewife (n=114). Eight scales from each fish 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) or as a first spawning virgin fish. Two readers, working independently identified first time (virgin) or repeat spawn (defined frequency). Samples that were not in agreement were examined by the team for a consensus determination. Blueback Herring, sexes combined, exhibited a virgin component of 70.7%, one repeat 25.1%, two repeat 3.7% and three repeat 0.5%. Analyses by sex, area, and other factors were all explored. The highest virgin component sample was from the Chicopee River (83%) with the lowest observed component from the Farmington River (61%) (Figure 4).

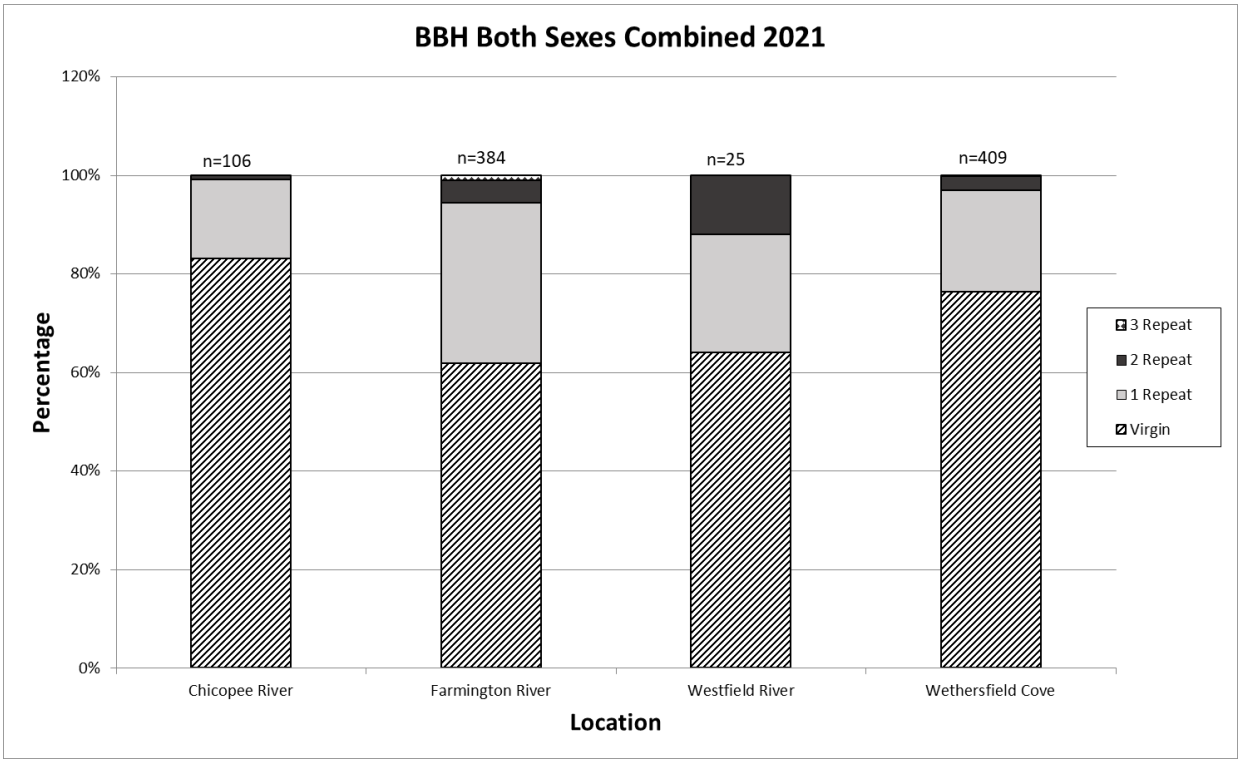


Figure 4. Spawning history of Blueback Herring (sexes combined) sampled in 2021 at the four primary sites: Wethersfield Cove, Farmington River, Westfield River and Chicopee River.

Length frequency plots describing size distributions by sex, over time, have been developed in aggregate and at the site-specific level.

Female Blueback Herring ovaries from laboratory processed fish were extracted and weighed over the field season (n=631). A consistent decreasing trend from early to late season sampled fish is described in Figure 5. These data and additional comparisons with the first season this were done (2019), will also be examined later.

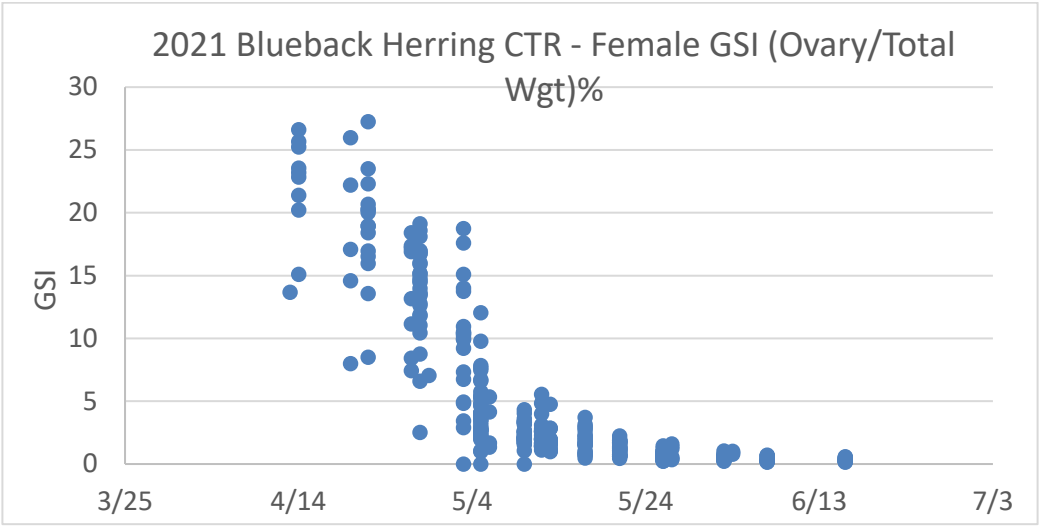


Figure 5. A plot of spring 2021 Blueback Herring female gonad somatic index (ovary wgt/total weight*100) as a percentage value over time, all site combined.

Connecticut River Adult Blueback River Herring Migration and Movement Study

In 2021 the Blueback Herring Migration and Movement Study done in partnership with the U.S.G.S. Conte Laboratory (Dr. Ted Castro-Santos co-Principal Investigator) was able to occur after being postponed in the spring of 2020. The delay in implementation allowed more acoustic tags to be purchased, bolstering the sample size. The tagging study was developed to address Connecticut River basin and broader scale management questions for blueback herring including: 1) Are BBH disproportionately using tributary and cove habitats vs. mainstem? 2) Is there movement among habitat types or retention and to what extent? 3) Does the run vary in accessing different habitat types and areas (e.g., reaching Holyoke Dam) over time? 4) What environmental factors (flow, temp) may influence migration (up and down), other movements and rates? 5) What other factors (run timing, sex, size) influence migration, movement, and rates? 6) Is there fidelity to spawning area (2-year returns)?

A total of 32 VEMCO VR2W receivers on moorings were deployed from the river mouth to the Holyoke Dam (rkm 139) with many receivers deployed in both coves and tributaries in March 2021. Live tended drift gill nets were fished (10-15 min sets) near the river mouth in April and May to capture blueback herring for the study (Figure 6). The net was 100 yards in length, 10 ft deep, and had a stretch mesh of 2.5 inches. Over sixteen dates, a total of 358 Blueback Herring and 88 Alewife were captured (Figure 7). Dr. Alex Haro (USGS Conte) provided training and necessary equipment for the tagging procedures and other Conte staff provided additional time and resources to this effort.

Image of the gill net being hauled in with fish being removed to live well; inserting a tag into a Blueback Herring; and preparing to release a batch of tagged and untagged fish from live car.

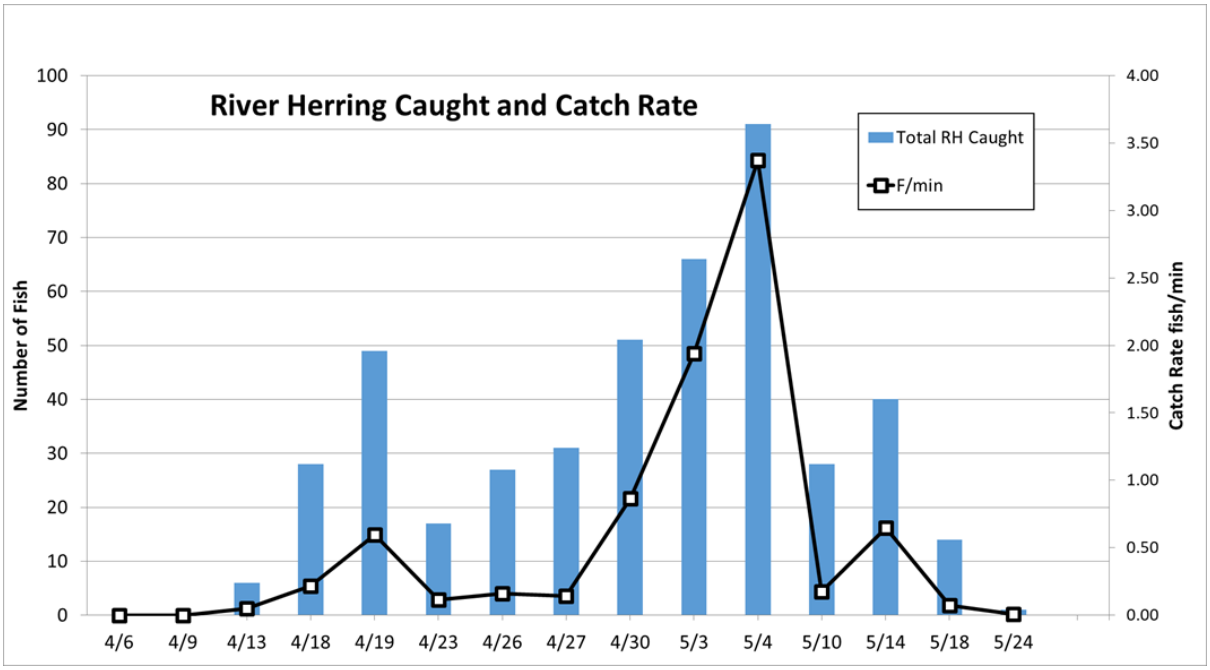


Figure 6. Catch rate of river expressed in fish -per-minute from gill net sampling in the spring of 2021 for acoustic tagging.

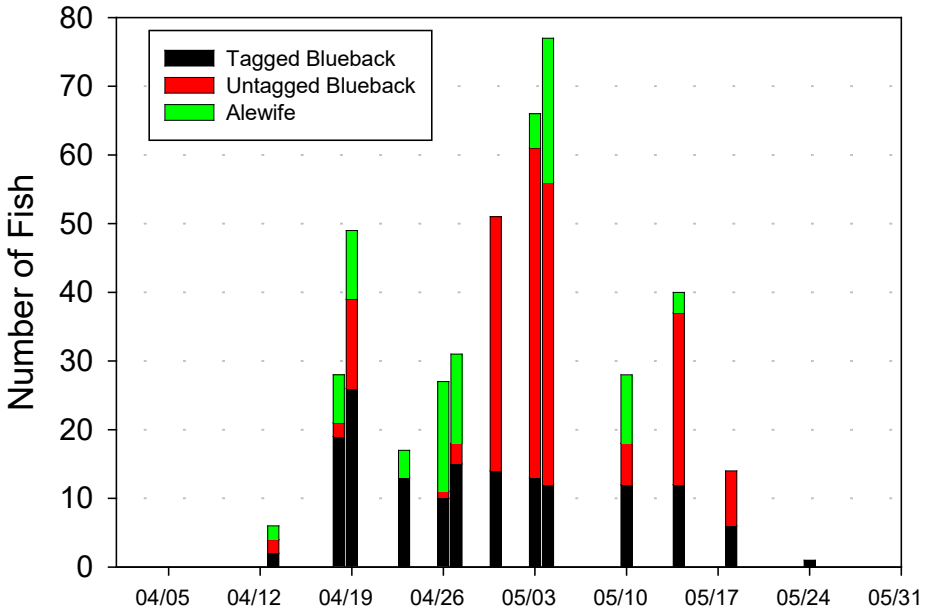


Figure 7. Blueback Herring captured with acoustic transmitter implanted, fish captured but not tagged, and Alewife also capture and not tagged.

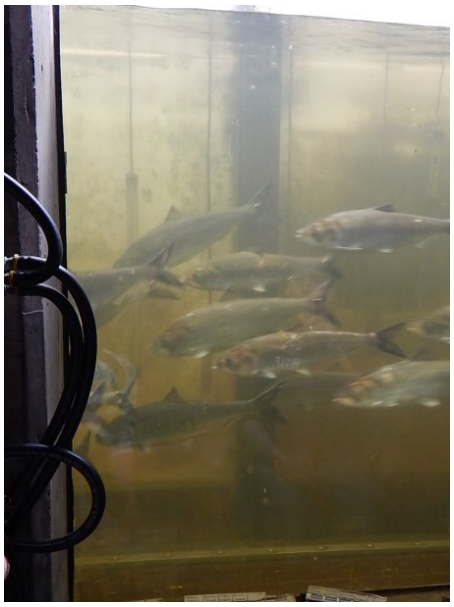
A total of 155, VEMCO V7 tags were surgically implanted in bluebacks with a single suture and cyanoacrylate glue applied. One hundred tags were programmed for 45 days on, then sleep for 300 days, then back on for ~45 days. The other 55 tags were holdovers from prior Covid cancelled 2020 field year and likely will not have a second year of battery life. All tagged fish were released in batches with untagged fish (both blueback and Alewife. In late summer 31 of

the 32 receivers were successfully retrieved and downloaded. Initial data checks showed a total of 108 tags (or 70% of tagged releases) detected at the first available upstream receiver, approximately 12 rkm upstream of the release site. These data and other tags detected on our receivers were under early screen review at the end of this reporting period. These data are part of the Mid-Atlantic Acoustic Telemetry Observation organization developed by/for researchers to share acoustic tag and receiver data among studies on the East Coast, increasing tag detection data spatially and temporally (https://matos.asascience.com/project/detail/184).

This 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).



Migratory Fish Returns

American Shad

A total of 237,355 adult American Shad were counted in 2021 at all first barrier passage facilities in the basin. A total of 237,306 American Shad were passed upstream of the Holyoke Dam, Massachusetts (river km 138), in 2021 through its two fish lifts, this is a 35% increase from 2020 (Figure 8). The mean annual passage count at Holyoke for the period 1976-2020 is 316,427 (±SD 129,058). The 25th and 75th percentile values for passage counts are 129,058 and 376,066 respectively. The Holyoke Fish Lift opened on 4/7/21 and had the following dates of non-operation due to early low water temperatures, high flows, and turbid conditions (4/10 – 4/11 and 4/30 – 5/9). On 6/17 the lift was not operated as Shortnose Sturgeon lift modifications were installed early, typically on 7/1, due to the planned lift shutdown in 2021 on 6/30. Holyoke Gas Electric (HGE) met with the agencies in the winter and reviewed the need for fish lift system maintenance review with needed replacement of many parts and components. The state and federal agencies approved that request which resulted in upstream passage measure for the lifts ending on 6/30/21. A digital image count system was operated with live counts from fishway staff for the Holyoke Dam fish passage facilities. Downstream passage measures and upstream passage measures for eel were maintained from spring startup through November.

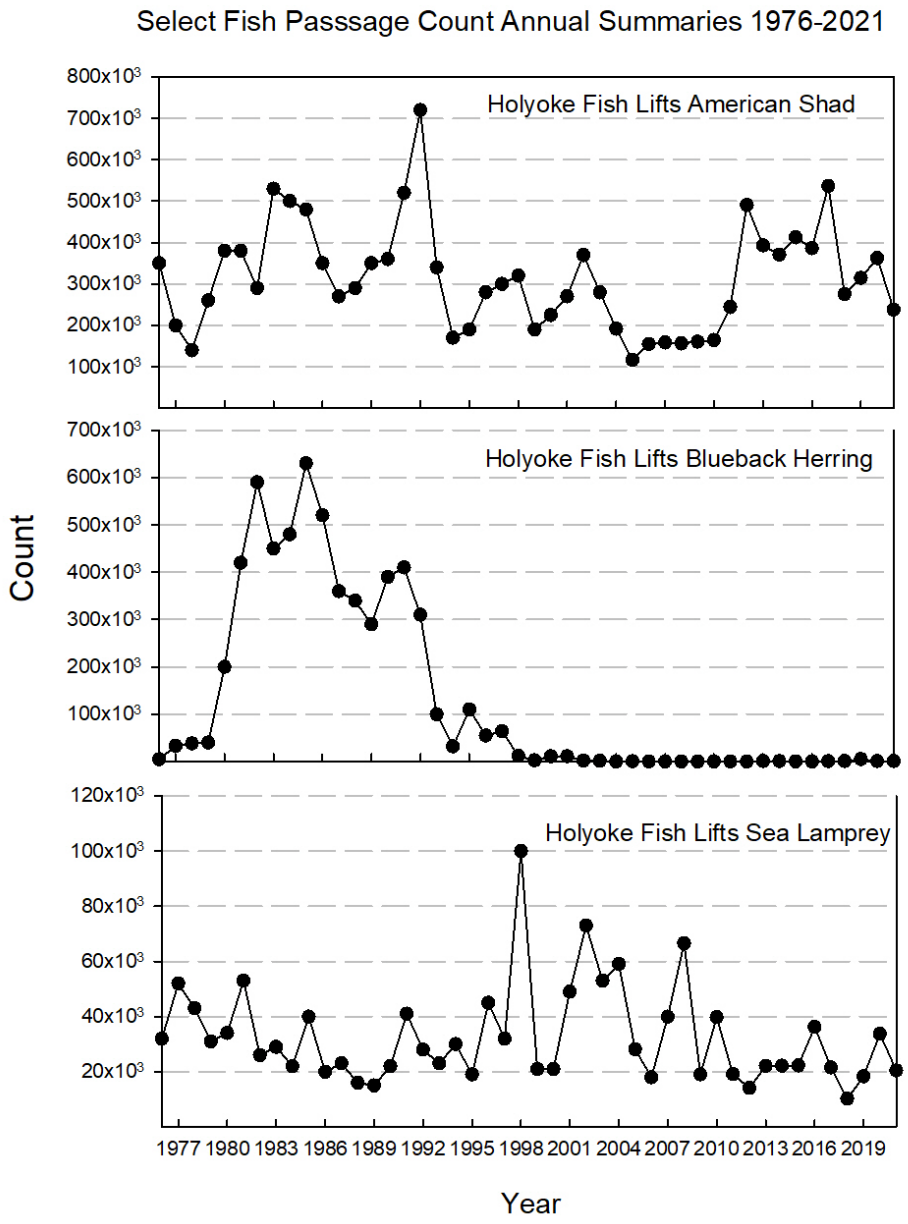


Figure 8. Select count summary of Holyoke Fish Lifts passage counts for American Shad, Blueback Herring and Sea Lamprey (1976-2021). Fish passage (counts) are affected by structural and operational changes at both dams and fishways and by environmental conditions (temperature and flow/spill) within year and among years.

The highest single passage date for shad occurred on 5/15/20 with 54,947 shad counted passing (Figure 9). Following the late April high flow event, river discharge receded to relatively low discharge levels without interruption through the end of upstream passage operations on 6/30.

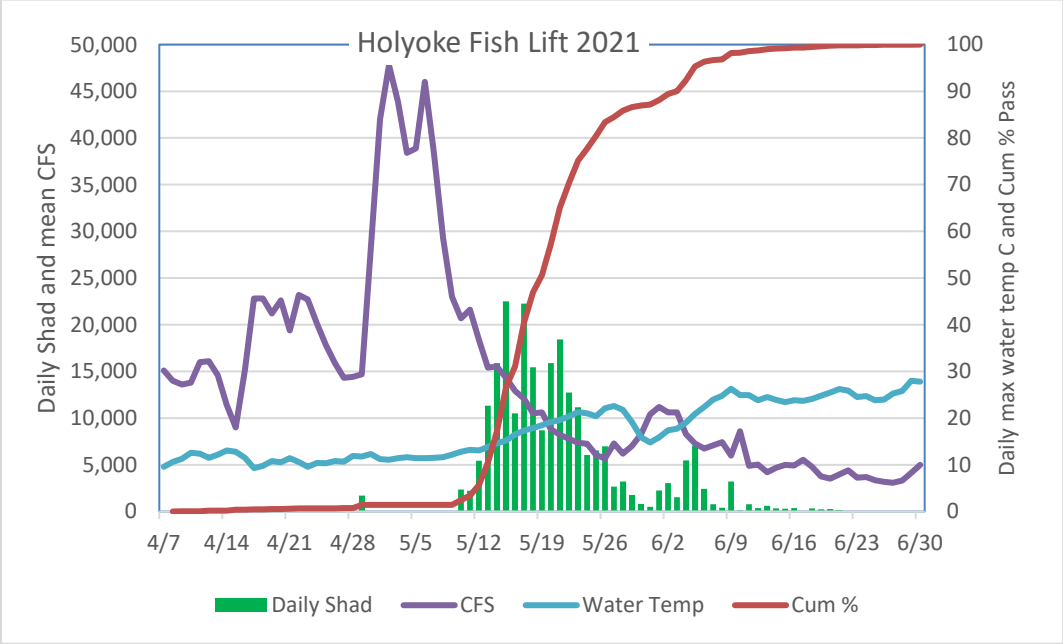


Figure 9. Daily American Shad passage counts from Holyoke Fish Lifts with water temperature and river discharge (USGS) data included for the period April 7 to July 1, 2021.

HGE in coordination with the agencies, agreed to trap-and-haul facility use for agencies located in Massachusetts for Covid protection measures in 2021. In 2020 there was no permitted trap-and-haul due to the Covid breakout at that time. The use of trap-and-haul at Holyoke supported research activities and the USGS Conte Laboratory, restoration activities by the USFWS North Attleboro National Fish Hatchery and fish health and age structure evaluation by the USFWS CTR FWCO (Table 6).

Table 6. Fish transfers from the Holyoke Fish Lift in 2021 by agency and use.

Agency	Species	Use	Number
USGS Conte Lab	American Shad	Passage research studies at the lab	1,090
USGS Conte Lab	Sea Lamprey	Passage research studies at the lab	70
USFWS North Attleboro National Fish Hatchery	American Shad	Broodstock for fry production and restoration stocking	300
USFWS CTR FWCO	American Shad	Fish health tests	60
USFWS CTR FWCO	American Shad	Scale and otolith comparison of structures for age	160

The three fish ladders at the Turners Falls Project were opened on 4/14/21 (Cabot Station) and 4/16/21 (Spillway Ladder and Gatehouse Ladder) following the requested CRASC Fish Passage Operations Plan for 2021. Fishway counts were provided at regular intervals by FirstLight Power with a total of 21,052 shad passing the Gatehouse Ladder at Turners Falls Dam in 2020, a substantial decrease from the 41,252 passed in 2020. 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. A total of 20,362 shad were counted passing into the power canal from the Cabot Station Ladder. A total of 12,789 shad were counted passing the Spillway Ladder. Spillway Ladder counted shad are believed to have limited fall back/loss (~ <10%) vs. those in the power canal. Fish in the canal must locate and use the Gatehouse Ladder entrances that are affected by several dynamic factors (e.g., turbulence, entrance gates attraction flow/locations). The Cabot Ladder was closed on 6/30/21 and the Spillway and Gatehouse ladders on 7/1/21.

Overall, the 2021 passage number at Gatehouse Ladder (requiring passage at noted two other ladders) as a percentage of American Shad passed at Holyoke Dam was 8.9% compared to 11.4% observed in 2020 (Table 7). 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 CRASC Shad Plan describes there is 1.4 times the amount of shad habitat upstream of the Turners Falls Dam versus the amount of habitat between Holyoke and Turners Falls dams. In addition, density dependent growth impacts have been documented for juvenile shad sampled in the Holyoke to Turners Falls reach, versus the upstream habitat reaches (Mattocks et. al 2019). These facts and additional management goals objectives of the CRASC Plan provide a clear rationale for the basis to achieve the defined passage performance criteria of the Plan and its Addendum on Fish Passage (CRASC 2017; as amended 2020).

Table 7. Annual American Shad upstream fish passage counts for listed fishways, starting in 1980.

Year	Holyoke Dam Passed	Turners Falls Dam Passed	TF % of Holyoke Total	Vernon Dam Passed	Vernon % of TF Total	Farmington River, Rainbow Dam Passed	Westfield River, W. Springfield Dam Passed
1980	376,066	**298**	0.1			480	
1981	377,124	200	0.1	**97**	48.5	167	
1982	294,842	11	0.0	9	81.8	737	
1983	528,185	12,705	2.4	2,597	20.4	1,565	
1984	496,884	4,333	0.9	335	7.7	2,289	
1985	487,158	3,855	0.8	833	21.6	1,042	
1986	352,122	17,858	5.1	982	5.5	1,206	
1987	276,835	18,959	6.8	3,459	18.2	792	
1988	294,158	15,787	5.4	1,370	8.7	378	
1989	354,180	9,511	2.7	2,953	31.0	215	
1990	363,725	27,908	7.7	10,894	39.0	432	
1991	523,153	54,656	10.4	37,197	68.1	591	
1992	721,764	60,089	8.3	31,155	51.8	793	
1993	340,431	10,221	3.0	3,652	35.7	460	
1994	181,038	3,729	2.1	2,681	71.9	250	
1995	190,295	18,369	9.7	15,771	85.9	246	
1996	276,289	16,192	5.9	18,844	116.4	668	**1,413**
1997	299,448	9,216	3.1	7,384	80.1	421	1,012
1998	315,810	10,527	3.3	7,289	69.2	262	2,292
1999	193,780	6,751	3.5	5,097	75.5	70	2,668
2000	225,042	2,590	1.2	1,548	59.8	283	3,558
2001	273,206	1,540	0.6	1,744	113.2	153	4,720

Year	Holyoke Dam Passed	Turners Falls Dam Passed	TF % of Holyoke Total	Vernon Dam Passed	Vernon % of TF Total	Farmington River, Rainbow Dam Passed	Westfield River, W. Springfield Dam Passed
2002	374,534	2,870	0.8	356	12.4	110	2,762
2003	286,814			268		76	1,957
2004	191,555	2,192	1.1	653	29.8	123	913
2005	116,511	1,581	1.4	167	10.6	8	1,237
2006	154,745	1,810	1.2	133	7.3	73	1,534
2007	158,807	2,248	1.4	65	2.9	156	4,497
2008	153,109	4,000	2.6	271	6.8	89	3,212
2009	160,649	3,813	2.4	16	0.4	35	1,395
2010	164,439	16,422	10.0	290	1.8	548	3,449
2011	244,177	16,798	6.9	46	0.3	267	5,029
2012[A]	490,431	26,727	5.4	10,386	**38.9**	174	10,300
2013	392,967	35,293	9.0	18,220	**51.6**	84	4,900
2014	370,506	39,914	10.8	27,706	**69.4**	536	4,787
2015	412,656	58,079	14.1	39,771	**68.5**	316	3,383
2016	385,930	54,069	14.0	35,513	**65.7**	141	5,940
2017	537,249	48,727	9.1	28,682	**58.9**	615	6,000
2018	275,232	43,146	15.7	31,724	**73.5**	341	5,752
2019	314,353	22,575	7.2	12,862	**57.0**	276	4,064
2020	362,423	41,252	11.4	13,897	**33.7**[B]	510	5,549
2021	237,306	21,052	8.9	9,701	**46.1**	47	N.A.
Mean	322,046	18,241		9,430		429	3,693
SD	129,821	18,209		12,201		445	2,154
Low	116,511	11		9		8	913
High	721,764	60,089		39,771		2,289	10,300

[A] Vernon Ladder issue fixed for 2012

[B] Vernon Ladder entrance gate issue identified 2022

2021 Westfield Ladder count system failure

The Vernon Dam (Vernon, Vermont) fish ladder was opened on 4/21/21 and closed on 7/15/21, following CRASC's operation plan. Fish counts started on 5/13/21 and concluded on 7/15/21 with 9,701 American Shad counted passing upstream. It is unlikely any shad passed prior to the count start on 5/13 as first few shad were first counted on 5/19 and consistently thereafter. Vernon Dam Ladder passed 46.1% of the American Shad counted passing from the Turners Falls Gatehouse Ladder in 2021. This proportion is an improvement from the 2020 "recent" lowest value. The causal (and fixable) factors for this were identified in 2021, not in time to implement necessary work for 2021 but will be before 2022 passage season. In 2020 extreme low river discharges in June occurred effecting tailwater elevations and in 2021, river discharge was also very low again in May and June (Figure 10). GRH identified an issue with the entrance gate range setting for the ladder entrance that was not adjusting to these very low tailwaters and created unfavorable entrance hydraulics, impacting fish entry. GRH has made the fix that will allow the gate to fully extend to necessary lower tailwater levels and GRH will automate its tracking of the gate and monitor its setting/adjustments with the tailwater elevation.

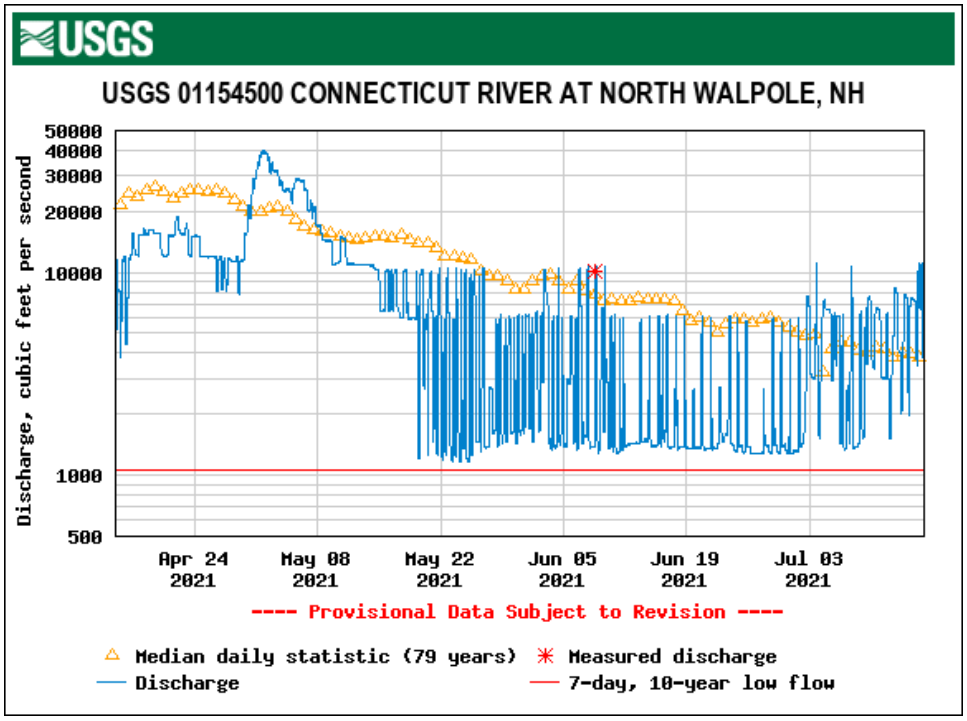


Figure 10. Daily average river discharge from first gage upstream of Vernon Dam, located 1 km downstream of Bellows Falls Dam for 4/15/21 through 7/15/21.

Bellows Falls Fish Ladder was opened on 5/26/21 and passed 2,183 Sea Lamprey (reason for ladder opening as target species) and 356 shad upstream. 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, to provide Sea Lamprey access to upstream habitats.

The West Springfield Fish Ladder on the Westfield River was operated in the spring of 2021 but had several substantial file corruptions from the digital image system (counting software system) that does not allow any basis to quantify fish passage for the spring season. A total of 47 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.

Shortnose Sturgeon – A total of 11 Shortnose Sturgeon (SNS) were trapped at Holyoke Fish Lift from lift operations in 2021, with the first fish captured on 4/16/21 and last on 6/19/21. Upstream passage operations were ended on 6/30/21 at Holyoke and were not restarted for the remainder of the year as discussed earlier due to unforeseen issues that emerged following the extended planned maintenance outage. The agencies, most notably NOAA, understood the circumstances of the situation of HGE as they provided updates, requests and coordinated with the agencies. This had an obvious impact on SNS passage based on past years data, as SNS counts often peak in summer months and continue into the fall. This is the sixth year of operations of the modified spillway lift entrance design to pass sturgeon, with annual counts tracking closely among the first 3 years and decreasing notably in 2019 and 2020 (Figure 11).

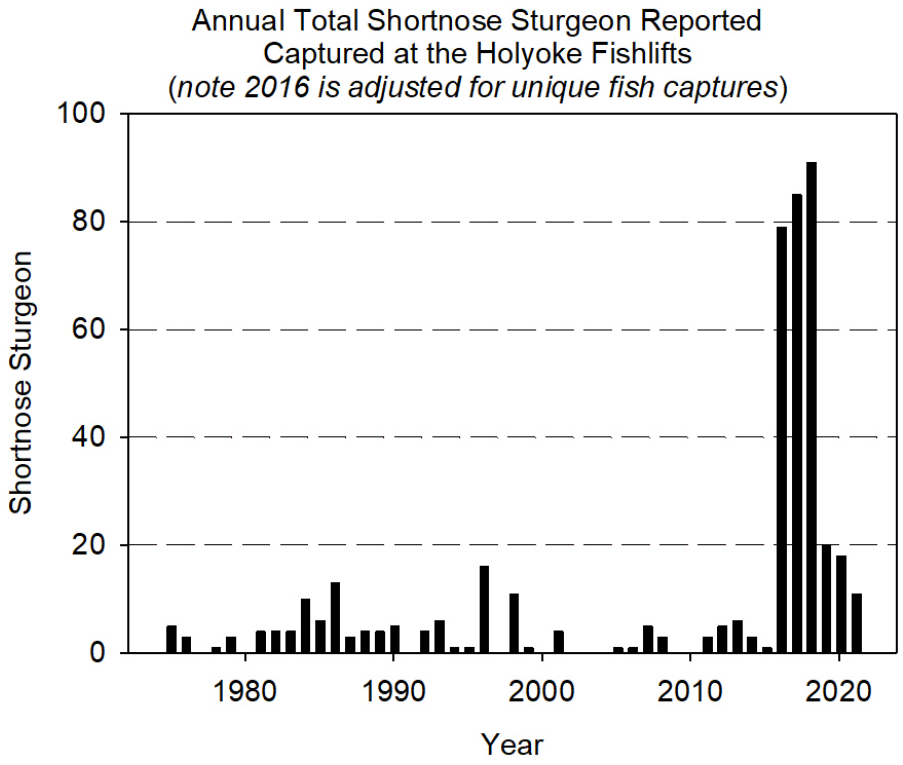


Figure 11. Annual total counts of Shortnose Sturgeon trapped at Holyoke Fish Lift 1975-2021. Sturgeon were not passed upstream until 2017, following an approved study plan to evaluate and monitor downstream passage.

Two important sturgeon findings were publicly reported by Jacque Benway (CTDEEP) and by Micah Kieffer (USGS Conte) at the June CRASC Technical Committee meeting. First, CTDEEP had been able to deploy egg mats in areas downstream of Holyoke Dam in April that collected over 70 eggs that were genetically confirmed as SNS as part of their Surgeon Research Grant with NOAA. Sampling was ceased by CTDEEP following the initial collection over a few sampling dates. Micah Kieffer was contacted by private consultants doing scuba work in the mainstem river in West Springfield in May on the observation of dozens of young-of-the-year SNS in the monitored area (work to protect freshwater mussels). Several images were provided confirming that report.

Blueback Herring - A total of 1,242 Blueback Herring were counted at the Holyoke Fish Lift in 2020 an increase from the 763 counted in 2020 (Figure 8). Four Blueback Herring were counted passing Turners Falls Gatehouse Ladder (Appendix A).

The CRASC River Herring Management Plan identifies an annual passage goal of 300,000-500,000 Blueback Herring at the Holyoke Fish Lift. That goal had been attained and exceeded up to the early 1990s, as population declines were being observed along much of the East Coast.

Sea Lamprey - A total of 20,620 Sea Lamprey were observed from first barrier fishway returning to the Connecticut River basin in 2021. This is a substantial decrease from the 2020 count for first barriers (37,399), driven primarily by the Holyoke Fish Lift, but observed among all counts.

The annual mean number of Sea Lamprey passed at Holyoke is 32,657 fish (1976-2020).

A total of 11,227 Sea Lamprey subsequently passed upstream of Turners Falls Dam (through Gatehouse Ladder), or 56% of the number passed at Holyoke (the proportion in 2020 was 52%). A total of 7,841 Sea Lamprey passed upstream of Vernon Dam (or 70% of the Gatehouse Ladder total) with 2,183 lampreys passed upstream of Bellows Falls Dam. In the lower river basin, 470 Sea Lamprey passed at Rainbow Dam versus 3,628 in 2020. No nest count surveys were conducted by CTDEEP in the Salmon River basin.

Striped Bass - A total of 352 Striped Bass were counted passing at the Holyoke Fish Lift in 2021 versus the 452 passed in 2020.

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 12,945 in 2021. This is a decrease from the 17,689 eels counted in 2020 (Figure 12). Eel ramps were deployed in May and June and operated through November 2021, with varied limited out-of-service periods. Eel ramp/traps are not checked on weekends after July 15. The Holyoke Gas and Electric Report on American Eel passage will be available in the winter of 2022 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.

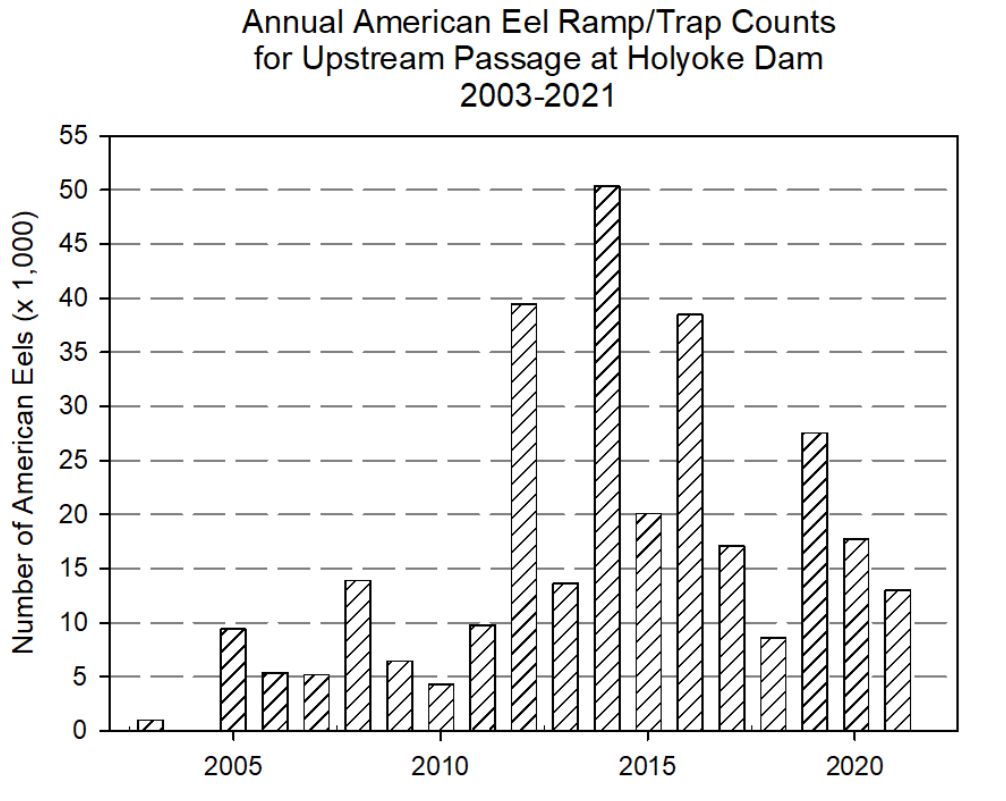


Figure 12. Annual American Eel ramp/trap counts reported by Holyoke Gas and Electric, at Holyoke Dam, for the period 2003-2021.

Atlantic Salmon – In 2021 there were three reported returns of sea-run adult Atlantic Salmon at the Rainbow Dam fishway on the Farmington River. Those fish were passed upstream. There were no reported adult salmon returns in 2020. Historically adult returns are dominated by four-year-old fish (age-2 smolt and two sea winter assignments).

Gizzard Shad - A total of 35 Gizzard Shad were counted at the Holyoke Fish Lift in 2021, an increase from the 66 observed in 2020.

Literature Cited

CRASC. 2017. Connecticut River American Shad Management Plan. Amended 2020, Fish Passage Performance Addendum. USFWS, 103 East Plumtree Road, Sunderland, MA. https://www.fws.gov/r5crc/pdf/CRASC-Shad-Plan-and-Addendum-3_2_2020.pdf

Mattocks, S., B. Keleher, and K. Sprankle. 2019. Juvenile American Shad assessment in the Connecticut River from Holyoke Dam to Bellows falls Dam, 2017-2018. USFWS, 103 East Plumtree Road, Sunderland, MA. https://www.fws.gov/r5crc/

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

Connecticut River Basin Fishway Passage Counts

Report Date: 12/30/2021

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 most 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
Rogers Lake-*CT*	final		2,507								
Mary Steube, Mill-*CT*	final		20,731								
Moulson Pond, Eightmile-*CT*	final		934	1,179							record # of ALE, been trucking
Leesville, Salmon-*CT*											
StanChem, Mattabesset-*CT*	final	2	5,198	598					19		
Rainbow, Farmington-*CT*	final	47			3	7	470				
W. Springfield, Westfield-*MA*											count equipment failures
Holyoke, Connecticut-*MA*	final	237,306		1,242		12,945	20,150	352	35	11	Closed 6/30 for repair work, not reopened in 2021
Easthampton, Manhan-*MA*											no counts
**Turners Falls-Gatehouse, Connecticut-*MA*	final	21,052		4			11,227				ladders closed 6/30 and 7/1
Vernon, Connecticut-*VT*	final	9,701					7,841				
Bellows Falls, Connecticut-*VT*	final	356					2,183				
*Total to basin, only **first** barrier counts*		237,355	26,863	3,019	3	12,952	20,620	352	54	11	
Last year totals		368,482	38,056	931	0	17,695	37,399	452	96	18	

*** Spillway Fish Ladder - at the dam 12,789 shad, 9,470 sea lamprey; Cabot Station Ladder, base of canal, 20,362 shad, and 11,616 sea lamprey. 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*

A - total collected from 3 eel ramp/traps at Holyoke in 2020

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 abundant 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 initially, and so elimination of these species progressed rapidly in these areas first, with settlement and use of early waterpower for mill power. 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. Both species were fished heavily in the river, most notably at the river's mouth on Old Lyme and Saybrook, Connecticut. 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. The lack of knowledge on how to manage the fisheries, how to deal with fish passage all contributed to the collapse of this initial restoration effort. However, information gains did occur on fish culture practices as that strategy was an answer to these issues of fish population declines.

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 a branch within 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. A Connecticut River Policy Committee comprised of the administrative heads of the resource agencies was the mechanism used to advance on restoration goals and objectives. Atlantic Salmon was a focus species 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 that demonstrated a ten-fold rate of return from stream reared smolts.

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 prior to 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 impacts from large scale shifts in marine conditions were also being observed in other Atlantic Coast salmon populations, both wild (Canada) and in various forms of active restoration (Maine, New Hampshire, Rhode Island).

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. There has also been a greater emphasis placed addressing safe, effective, and timely downstream passage of fish and lifestages which has presented challenges that have been worked on through new approaches, research, and evaluations.

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 understanding and attempted to resolve (some of these) over the years with our 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 fish passage 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, repeat spawner component) 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 30–50-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.