JOB 7: ALOSINE SURVEY

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GOAL

Goal: Monitor abundance and distribution of American shad and forage species in Connecticut's major rivers and nearshore waters.

OBJECTIVES

Provide:

1) Information characterizing adult American shad spawning populations: size composition, age structure, spawning history, and sex ratio.

2) Annual indices of relative abundance for juvenile shad and forage species.

STUDY PERIOD AND AREA

This report contains information on adult American shad monitoring and seine studies on juvenile American shad (*Alosa sapidissima*) and common nearshore species in 2021. Areas of the Connecticut River sampled, range from Holyoke, MA to Essex, CT. Time series data collected under previous funding sources are also included for comparative purposes.

INTRODUCTION

Annual spawning migrations of American shad in the Connecticut River have supported both recreational and commercial fisheries in the State of Connecticut, as well as recreational fisheries in upriver states, for generations. There are currently small commercial and recreational fisheries that occur in the Connecticut portion of the Connecticut River. The Connecticut River is the only river system in the state that allows shad harvest and requires annual licenses for both commercial and recreational fisheries. Sustainable fisheries for states have been managed since 2012 under the Atlantic States Marine Fisheries Commission (ASMFC) Amendment 3 to the coast wide Fishery Management Plan for American shad. Connecticut monitors 3 metrics on an annual basis to determine the overall sustainability of the shad stock. Sustainability metrics are: fish passage counts for adults, relative juvenile abundance, and adult escapement. The commercial fishery is managed through area, gear, seasonal restrictions, and rest days. The recreational fishery is managed through a daily bag limit of 10 fish (a combined aggregate of American and hickory shad).

Historically, American shad were one of Connecticut's top five most economically important commercial finfish species in terms of landings. The commercial fishery occurs in the main stem of the Connecticut River south of the Putnam Bridge in Glastonbury, CT. Commercial data are

collected from mandatory annual reporting of landings from commercial shad license holders. Landings information is compiled and used to estimate the maximum losses to the spawning stock from fishing. The recreational fishery predominantly occurs north of Hartford, CT at River Kilometer (RKM) 83 and south of the Holyoke Dam in Massachusetts (RKM 139). Information on the recreational fishery in CT was last collected by a roving creel survey conducted in 2010. In 2023, the Connecticut River Conservancy is working with CT DEEP and other partnering agencies, to develop a Connecticut River Creel Survey in areas where the shad recreational fishery occurs.

The Connecticut Department of Energy and Environmental Protection (CT DEEP) has conducted annual fisheries independent research studies on adult American shad in the CT River since 1974, to monitor annual changes in stock composition. Holyoke Gas and Electric (HGE) monitors fish passage, which includes adult American Shad passage, at the first main stem dam on the CT River in Holyoke, Massachusetts. The HGE staff compiles daily tallies of fish passed through the fish lift facility, samples periodically for size structure and sex ratio, and collects scale samples. CT DEEP processes and interprets scale samples collected by HGE staff to estimate age structure and spawning history (i.e. proportion of the run comprised of repeat spawners).

Juvenile shad are monitored by CT DEEP through an annual seine survey conducted since 1978. The seine survey provides an annual index of relative abundance for juvenile American shad, which is used to characterize year class strength and potential recruitment to the spawning run in future years.

METHODS

American shad adults

Fishery Dependent Data

Commercial fishermen are required by regulation to report daily landings and fishing effort for American shad annually to CT DEEP. Landings information was compiled and used to estimate the maximum losses to the spawning stock from fishing. Harvest was tallied by pounds of shad landed by sex.

Fishery Independent Data

Holyoke Lift

Scale samples from American shad are collected by Holyoke Gas & Electric (HGE) staff, at the Holyoke Dam Fish Lift, located at river kilometer 139, in Holyoke, MA. In 2021, all trapping and biological sampling of American shad was resumed as state and local restrictions related to the COVID-19 pandemic were lifted. Daily counts of American shad at the fish lift were collected. Information on the number of fish lifted daily and the number of lift days (days the lift is in operation) at Holyoke were collected and obtained from the HGE staff.

Adult shad collected at the Holyoke Lift are sexed, measured to fork length (mm), weighed (g), and 15-25 scales are removed. Scale samples collected are separated by sex and stratified into 1 cm length groups. All viable scale samples collected were cleaned with an ultrasonic cleaner, dried and mounted between 2 glass microscope slides.

Scales are magnified with a microscope using transmitted light, viewed through a Luminera camera, and displayed on a computer screen using Image Pro Premier Software. Digital photos are taken of each sample and cataloged. Image files of each scale sample are identified only by a sample number.

Age determinations were made with consensus of two or more readers on the displayed images by counting annuli and spawning scars according to the criteria of Cating (1953). When discrepancies between the two readers could not be resolved, the scales were examined by a third reader. Samples that were poor quality or did not have two or more viable scales were not aged. Shad were noted to be repeat spawners when the presence of spawning scar(s) at the periphery of the scale were identified. All annuli and spawning scars on scale images were digitally marked and stored as a line profile using Image Pro Premier Software.

Prior to 2015, Scale samples were processed by cleaning with an ultrasonic cleaner and pressed onto acetate using a roller press. The pressed scale images were read using a microfiche reader. When the new image analysis system was implemented, comparisons of scale ages were made using both the Microfiche and Image analysis equipment to ensure that the interpretation of scale ages remained consistent.

Juvenile Seine Survey

A single seine haul was conducted at fixed site locations, one day a week, from mid-July through mid-October. Seine haul locations and techniques were identical to those used in past Connecticut River seine surveys. The sampling sites were previously chosen based on location, physical conditions, and accessibility (Crecco et al. 1981; Marcy 2004). The stations were sampled during daylight hours with an 18.3 m nylon bag seine (0.5 cm delta mesh) and 30.5 m lead ropes. The seine was fished with the aid of a boat to deploy it upstream and offshore to sweep down through the site. Using the lead ropes, the seine was towed in a downstream arc to the shore and hauled by hand in to shore. Clupeids (*Alosa sapidissima, A. aestivalis, A. pseudoharengus*, and *Brevoortia tyrannus*) were returned to the laboratory for measurement and identification. All fish species other than family clupeidae, were identified, quantified, or estimated and released. Invertebrate species are either counted or noted as present. In the laboratory, juvenile clupeids were identified to species by the criteria of Lippson and Moran (1974) and counted. For each sample, up to 40 randomly selected clupeids of each species were measured to total length (mm).

A relative abundance index for young of the year American shad was calculated as a geometric mean catch per unit effort. The geometric mean is the preferred method when reporting to ASMFC for annual compliance reports because it normalizes clustered data. See Job 5 (Gottschall et al. 2021) for methods used to calculate the geometric mean. Forage species are reported as percent occurrence.

RESULTS

Results collected during the funding timeframe of March 1, 2021 through February 28, 2022 are presented below. The field activities and sample collections in 2021 for the alosine project continue

to be challenging due to staffing shortages and changing environmental conditions. Time series data presented includes past sampling efforts, when work was funded by other sources.

Commercial Fishery Landings

The Connecticut River American shad commercial fishery reported a total catch of 25,001 lbs in 2021 (Figure 7.1). Participation in the commercial American Shad fishery remains at low levels as 3 boats reported landings and 6 commercial shad licenses were sold in 2021. The number of shad boats fishing annually continues to remain low as few new participants enter the fishery. Commercial shad landings represent less than 2% of the total number of shad reported at the Holyoke fish lift in 2021.

Commercial shad catch reports were skewed towards females (94%), with males accounting for 6% of the reported landings (Table 7.1). Males are most likely underreported and less represented in the catch due to mesh size selectivity. Male shad are often discarded because they are less valuable to sell to markets.

Connecticut River Adult American Shad Age Structure

The shad sample collections at the Holyoke fish lift were resumed in 2021, following the relaxation of Covid-19 safety restrictions. The Holyoke Fish Lift was still operated using limited staff. Manual fish counts were collected and a back-up video recording system and software was used to supplement and/or confirm manual counts. Early morning and late evening passage operations commenced once the shad run reached around 7,000 fish as a daily total.

The Holyoke Fish lift was open for fish passage from April 7 through June 30, 2021. Fish passage operations were halted during April 10,11 (due to low returns and low temperatures) and from April 30-May 9, due to high river discharge and poor viewing visibility. There was an early shutdown of the lift on June 8 (weather concerns) and a closure on June 17 (equipment installation).

The water temperatures during the 2021 fish passage season ranged between 10-15 degrees C during mid-April through early May. By the end of May, temperatures had increased to 20 degrees C. The peak period of shad passage occurred during increases in water temperature occurring during the third week of May. River discharge declines coincided with increases in temperature (Figure 7.2).

The number of American shad lifted upstream annually at the Holyoke Dam (Figure 7.3) has been highly variable through the time series, however 2021 was below the long term mean of 310,180, (Normandeau 2022).

For the 2021 biological sampling, there were 876 American shad collected for scale samples, representing 0.37% of the annual fish passage count. Scale samples were collected over 51 dates from April 12 through June 24. Samples were collected during 99% of the days when shad passage occurred at the lift (Normandeau 2022).

The 2021 shad run sex ratio and length frequency (Figure 7.5), was derived from information collected at the Holyoke fish lift which is located at River Kilometer 139, upstream of both the commercial and sport fisheries. The combined impact of these modest fisheries is likely not significant enough to affect the composition of the run. The 2021 weighted sex ratio of shad sampled at Holyoke was 39% male and 61% female. As is typical, the male fish are smaller in size than females.

Length frequency of American shad collected at the Holyoke lift in 2021 ranged from 305-487 mm FL for male shad and 351-514 mm FL among female shad. The average size among males was 408 mm FL and among females was 453 mm FL.

The preliminary age examination of the 2021 scale samples was completed, but due to staffing shortages, the data QA/QC has not been completed in time for this report. Recommendations from the 2020 Atlantic States Marine Fisheries Commission Benchmark Stock Assessment of American Shad include incorporating otolith ages as the preferred method for aging. Because otolith extraction requires the sacrifice of fish, it is unknown when CT DEEP would be able to obtain access to suitable sample sizes of shad otoliths. Processing and imaging otoliths would be an additional time and staff commitment. One benefit of aging scales is that the spawning history can be determined from the scale image. The ability for existing CT DEEP staff to obtain and process both scales and otoliths is not possible, at this time.

Juvenile Seine Survey

Sampling occurred for juvenile alosines in the Connecticut River from July 8 through September 30, 2021. A total of 2,989 juvenile American shad were collected for the season (Table 7.3). The highest catch in 2021 was 1,011 shad collected at the Wilson site in late September, representing 33% of the total catch for the season (Table 7.3). The Holyoke site total catch of 1,941, represented 65% of the annual catch. The catches at the subsequent sites represented 4%,2%,15%,11% and 3%. The 2021, geometric mean catch per unit effort value for American shad was of 16.68 and is indicative of a strong year class in the time series.

The Glastonbury station, has become increasingly difficult to sample due to the silt & mud river bottom, in addition to the infestation of the invasive aquatic vegetation, *Hydrilla verticillata*. Additional changes in land cover have resulted in sampling difficulties at all sites. Physical challenges impacting the hand-hauled seine gear include: bank erosion, fallen trees, increased siltation, and high levels of aquatic vegetation.

In the 50 hauls completed in 2021, over 15,000 fish were collected representing 31 species or taxonomic groups (Table 7.5). To minimize mortality and to facilitate returning large catches of fish quickly to the water, some fish were identified only to the family or genus level (e.g. sunfish, catfish, killifish). Large catches of common species estimated with a visual count to minimize handling and processing time. Blueback herring were collected at the stations in Deep River and Essex, CT, totalling 2,004 fish (Table 7.3). Menhaden were also collected in the lower river stations and totaled 847 fish (Table 7.4). In 2021, the five most abundant species or groups collected were shiners, American shad, blueback herring, sunfish, and menhaden (Table 7.5).

Additional Activies:
Land Use Land Cover Change (LULCC) StoryMap of CT River Seine Survey Sites

The Marine GIS project in collaboration with staff from the Alosine Survey, developed an ESRI Storymap that examined the physical changes of land surrounding the CT River seine survey sites within CT (1965-2016). The StoryMap was published on the CT DEEP website https://ctdeep.maps.arcgis.com/apps/MapJournal/index.html?appid=ecf0a13f2f804df881b7d150ec654747

Prior to the publication of the StoryMap, the observations of physical changes to the seine sites were observed, but not documented. Historical Aerial imagery available for CT sites was obtained and compared over the decades using a methodology created by the University of Connecticut Center for Land Use Education and Research. A description of the methodology is outlined in the StoryMap.

While it's difficult to draw definitive conclusions as to the impacts on the land cover change on juvenile shad habitat, there were noticeable trends in declines of deciduous forest, declines in land used for agricultural purposes, and increases in development which includes impervious land cover.

There have also been significant physical changes river itself, particularly with the increased growth of aquatic vegetation. Further investigation is needed to determine the impacts on shad habitat at the fixed locations of the seine sites.

Interstate fisheries management accomplishments

During this project segment the ASMFC benchmark coast wide stock assessment was completed and peer reviewed in May of 2020. The CT River portion of the American shad stock assessment included fishery dependent and independent time series data. The American shad stock assessment subcommittee accepted the use of commercial shad fishery landings, the CT River seine survey YOY index, the adult American Shad age structure data, and annual fish passage counts at the Holyoke Dam as part of the assessment analyses. The full details of the coast wide stock assessment are available on the ASMFC website www.asmfc.org/uploads/file/5f999ba1AmShadBenchmarkStockAssessment_PeerReviewReport_2020_web.pdf

As part of the ASMFC requirements for Amendment 3 of the American Shad Interstate Fishery Management Plan, a significant revision of the original 2013 shad habitat plan was approved by the Management Board. Information provided included a habitat assessment, threats assessment, and description of the state's habitat restoration program. The final version of the 2021 American Shad Habitat Plan for CT is on the ASMFC website-CT_ShadHabitatPlan_2021.pdf (asmfc.org).

Data Requests
Juvenile alosine finclips were provided to the USGS Leetown Science Center,to identify single nucleotide polymorphisms (SNPs), for the genetic stock identification of American shad and

river herring. CT DEEP provided fresh and frozen samples for: Alewife (72), American Shad (162), Blueback Herring (66), and Hickory shad (3).

Juvenile blueback herring length frequency data from the seine survey was provided to a graduate student at the University of Massachusetts Amherst

MODIFICATIONS

As staffing limitations for alosine work remain limited, CT DEEP is working to determine what level of alosine monitoring can continue. In addition, the challenges associated with land cover changes and nearshore invasive aquatic vegetation infestations necessitate evaluation of the efficacy of seine gear used in the CT River juvenile alosine survey.

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Table 7.1. Annual American shad commercial fishery harvest. Landings are reported by weight (lbs.) and by sex, 2009-2021.

Year	Total (lbs)	Male Wt (lbs)	Female Wt (lbs)
2009	40,680	4,045	32,187
2010	24,641	2,994	21,192
2011	32,805	3,354	29,451
2012	61,975	10,187	51,788
2013	63,324	10,406	52,918
2014	62,707	7,789	54,918
2015	52,713	6,661	46,052
2016	33,998	3,081	30,917
2017	42,191	6,589	35,602
2018	19,939	1,606	18,334
2019	5,496	426	5,070
2020	21,414	3,411	18,004
2021	25,001	1,546	23,455

Table 7.2 Seine Survey catch and effort for CT River juvenile American shad, 2021.

Date	HOLYOKE	WILSON	GLASTONBURY	SALMON RIVER	DEEP RIVER	ESSEX	Catch	Effort
7/8/2021	16	0		60	70	12	158	5
7/29/2021	128	24		12	49	1	214	5
8/5/2021	173	26		17	77	35	328	5
8/12/2021	185	12		48	10	1	256	5
8/19/2021		10	61	102	15	0	188	5
8/26/2021	26	14		111	5	17	173	5
9/9/2021	195	9		3	7	3	217	5
9/15/2021	207	21		62	24	5	319	5
9/23/2021	1011	1		6	4	1	1023	5
9/30/2021	0	0		17	81	15	113	5
Total	1941	117	61	438	342	90	2989	50

Table 7.3 Seine Survey catch and effort for CT River juvenile blueback herring, 2021.

Date	HOLYOKE	WILSON	GLASTONBURY	SALMON RIVER	DEEP RIVER	ESSEX	Catch	Effort
7/8/2021	0	0		20	338	15	373	5
7/29/2021	0	0		0	2	0	2	5
8/5/2021	0	0		0	0	2	2	5
8/12/2021	0	0		2	13	0	15	5
8/19/2021		0	8	496	369	0	873	5
8/26/2021	0	1		141	5	4	151	5
9/9/2021	0	0		0	0	7	7	5
9/15/2021	0	0		85	28	19	132	5
9/23/2021	0	0		0	33	0	33	5
9/30/2021	0	0		48	292	76	416	5
Total	0	1	8	792	1080	123	2004	50

Table 7.4 Seine Survey catch and effort for CT River juvenile menhaden, 2021.

Date	HOLYOKE	WILSON	GLASTONBURY	SALMON RIVER	DEEP RIVER	ESSEX	Catch	Effort
7/8/2021	0	0		0	0	0	0	5
7/29/2021	0	0		0	0	0	0	5
8/5/2021	0	0		0	0	1	1	5
8/12/2021	0	0		0	0	20	20	5
8/19/2021		0	0	24	50	17	91	5
8/26/2021	0	0		0	0	5	5	5
9/9/2021	0	0		0	0	166	166	5
9/15/2021	0	0		1	0	54	55	5
9/23/2021	0	0		0	0	9	9	5
9/30/2021	0	0		0	0	500	500	5
Total	0	0	0	25	50	772	847	50

Table 7.5 Geometric mean relative abundance index (CPUE) of juvenile American shad(ASD), 1978-2021.

Year	Juv ASD	Year	Juv ASD
1978	5.89	2000	4.42
1979	7.84	2001	2.73
1980	9.21	2002	5.55
1981	6.05	2003	6.88
1982	1.81	2004	5.62
1983	4.99	2005	10.08
1984	3.37	2006	1.82
1985	7.14	2007	8.15
1986	6.29	2008	5.06
1987	9.89	2009	3.40
1988	5.68	2010	10.23
1989	4.85	2011	3.08
1990	10.39	2012	3.03
1991	4.26	2013	3.16
1992	7.55	2014	8.09
1993	9.49	2015	8.53
1994	12.22	2016	16.70
1995	1.34	2017	5.00
1996	6.50	2018	22.76
1997	7.15	2019	4.52
1998	3.65	2020	Incomplete sampling
1999	5.47	2021	16.68

Table 7.6. List of fish species or group and percent frequency of occurrence of fish collected in Connecticut River seine survey, 2021.
**includes more than one species*

Species or Group	% abundance	Species or Group	% abundance
Alewife	0.12	Menhaden	6.69
American Eel	0.08	Chain Pickerel	0.04
American Shad	19.26	Rock Bass	0.64
Atlantic Silverside	1.11	Smallmouth Bass	0.34
Bay Anchovy	1.38	Shiner*	40.80
Black Crappie	1.36	Striped Bass	0.03
Blue Crab	0.17	Stickleback*	0.02
Blueback Herring	13.44	Sunfish*	7.85
Bluefish	0.03	Tesellated Darter	0.24
Bowfin	<0.01	White Perch	0.04
Carp	0.02	White Sucker	0.37
Catfish*	0.13	Yellow Perch	0.34
Crayfish	0.03		
Fallfish	0.16		
Golden Shiner	0.21		
Hogchoker	0.03		
Killifish & Mummichog*	4.47		
Largemouth Bass	0.59		

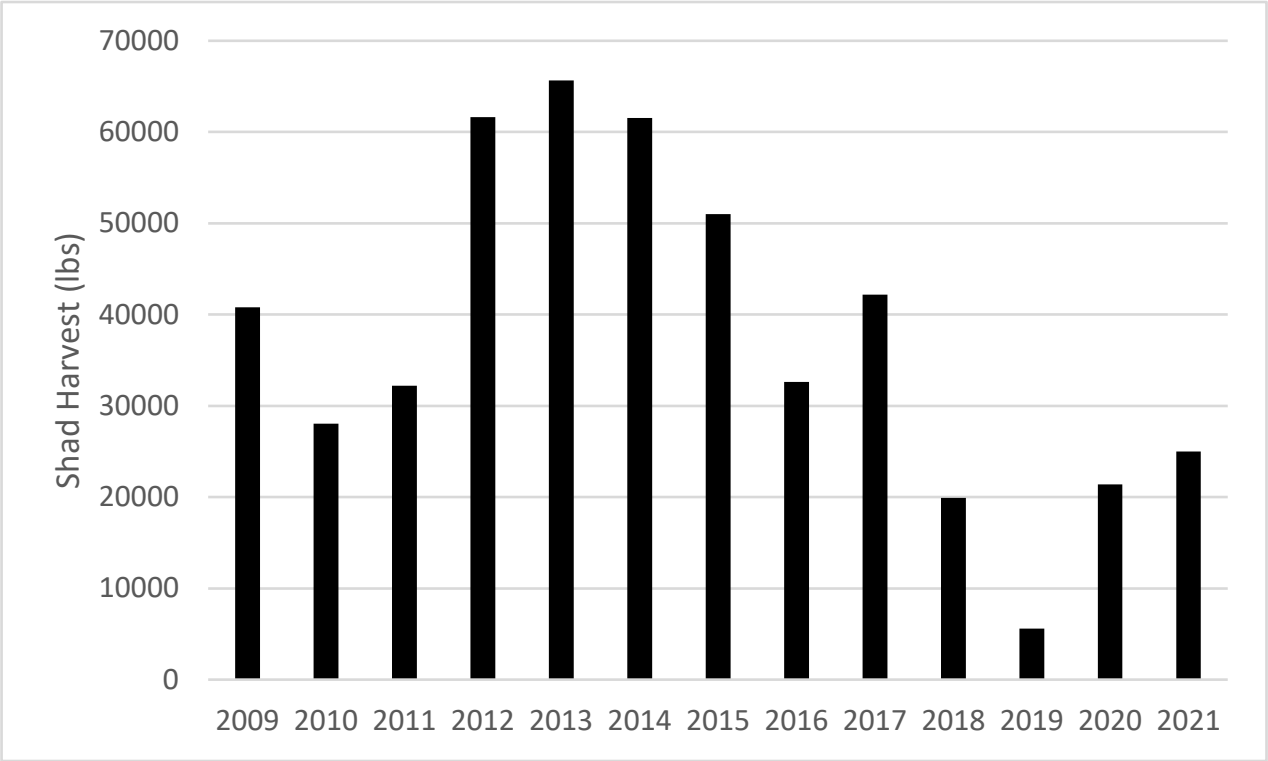

Figure 7.1. Commercial Landings (lbs) for CT River adult American shad, 2009-2021.

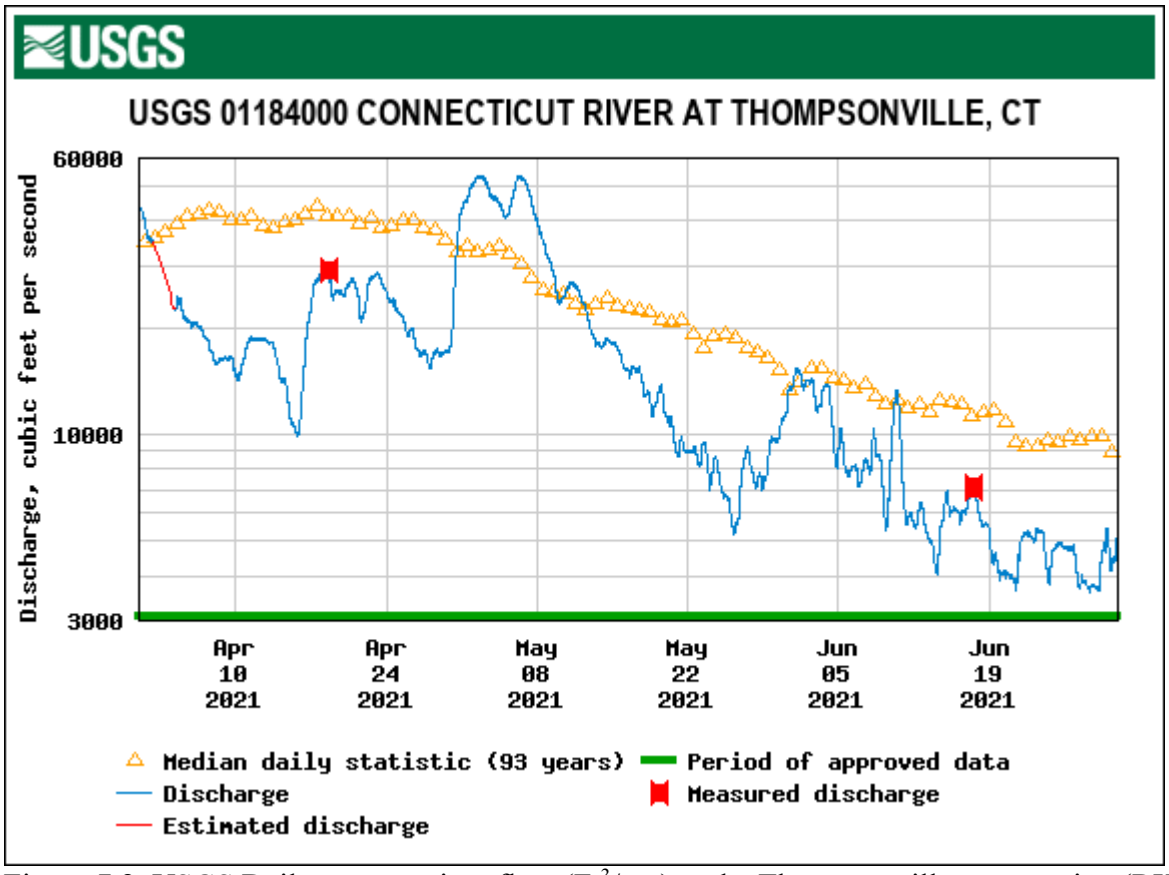

Figure 7.2 USGS Daily average river flow (Ft^3/sec) at the Thompsonville gage station (RKM 110) compared to median flows, during 2021 American Shad passage.

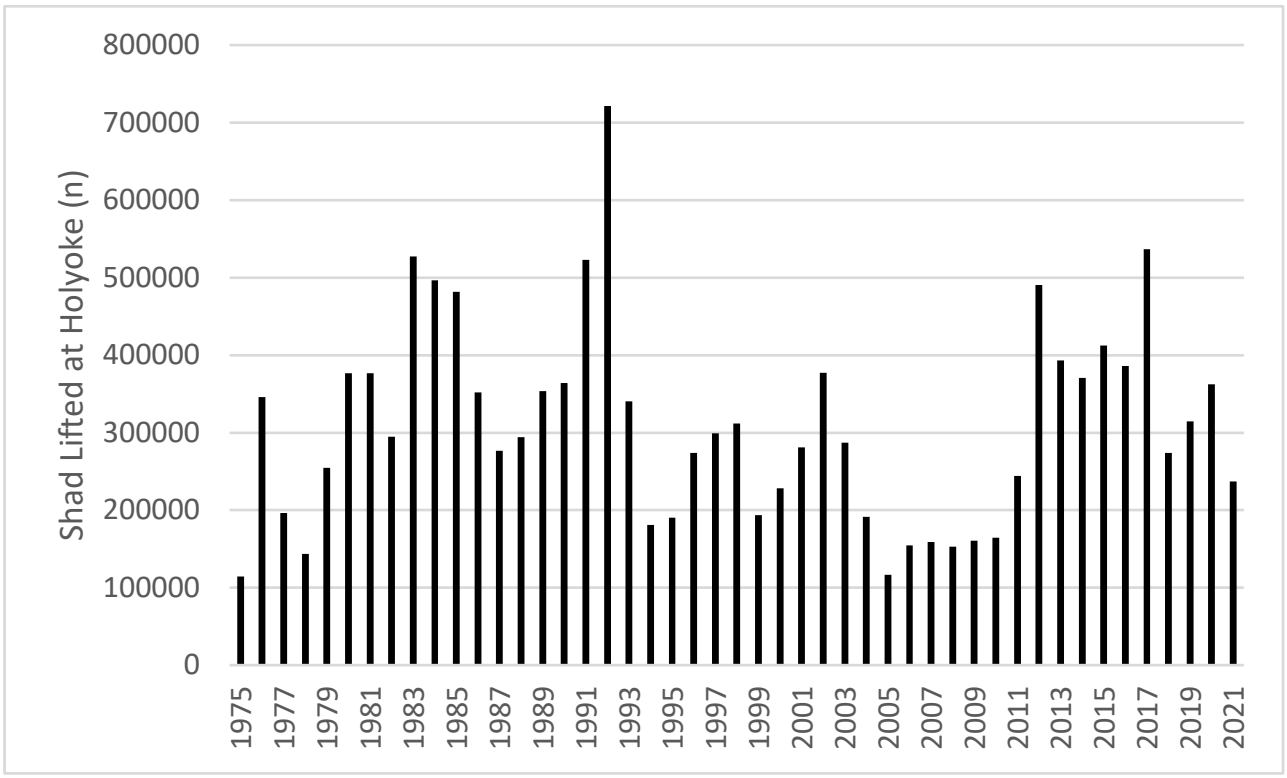

Figure 7.3 Number of adult American Shad lifted at the Connecticut River Holyoke Dam (RKM 139), 1975-2021

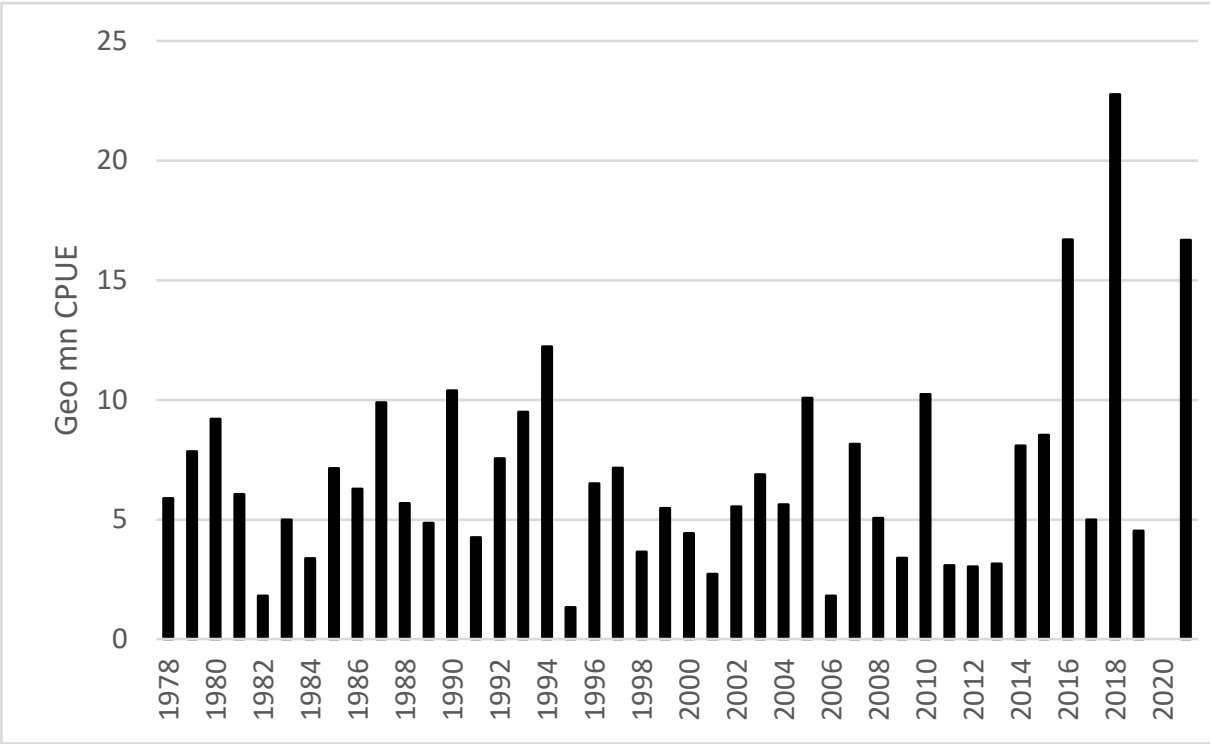

Figure 7.4 Annual geometric mean catch per unit effort of Connecticut River juvenile American shad by station,1978-2021. Index could not be calculated in 2020 due to low sample size.

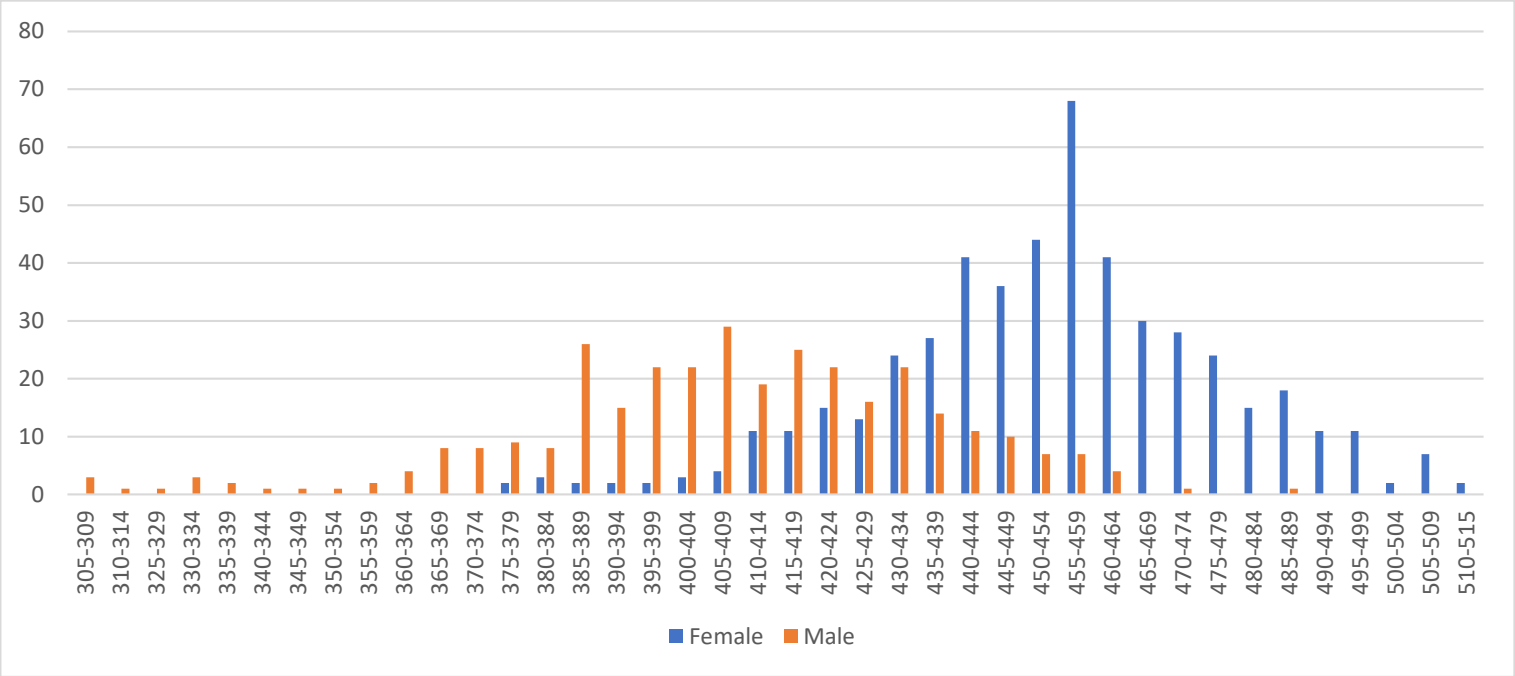

Figure 7.5. Length frequency (mm) of American shad, sampled from the Holyoke Lift,by sex.