# JOB 7: ALOSINE SURVEY

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## JOB 7: ALOSINE SURVEY

## 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 2022. 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 ranked among the top five most economically significant commercial finfish species in Connecticut in terms of landings. The commercial fishery is conducted in the main stem of the Connecticut River, south of the Putnam Bridge in Glastonbury, CT. Data for this

fishery is collected from mandatory annual reports of landings by commercial shad license holders. This information is compiled and used to estimate the maximum losses to the spawning stock from fishing.

The recreational fishery predominantly takes place north of Hartford, CT at River Kilometer (RKM) 83 and south of the Holyoke Dam in Massachusetts (RKM 139). The last collection of information on the recreational fishery in CT was conducted through a roving creel survey in 2010. In 2023, the Connecticut River Conservancy proposed a pilot Connecticut River Creel Survey in Massachusetts and northern Connecticut.

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 2022, trapping and biological sampling of American shad occurred and daily counts of American shad at the fish lift were documented. 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 using 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. 2022) for methods used to calculate the geometric mean. Forage species are reported as percent occurrence.

## RESULTS

The results gathered from March 1, 2022, through February 28, 2023, are detailed below. The alosine project's field activities and sample collections in 2022 were notably challenging due to staffing shortages and challenging environmental conditions. The dense growth of aquatic invasive vegetation, especially Hydrilla, continues to make it difficult for survey staff to access nearshore seine site locations. The time series data provided includes previous sampling efforts funded by other sources.

**Commercial Fishery Landings**

In 2022, the commercial fishery for American shad in the Connecticut River reported a total catch of 15,827 lbs (Figure 7.1). While only five boats reported landings and eight commercial shad licenses were sold, participation in the fishery remains low. The number of boats fishing for shad each year continues to be minimal due to the lack of new entrants into the fishery. Commercial shad landings accounted for approximately 8% of the total number of shad reported at the Holyoke fish lift in 2022, which provides a minimal estimate of the total population.

Commercial shad catch reports were skewed towards females (87%), with males accounting for 13% 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 conducted following normal operating procedure in 2022. Manual fish counts were collected throughout the season, 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 a daily total of 12,500 fish from the previous day.

The Holyoke Fish lift was open for fish passage from April 6, 2022. Ice buildup delayed the start of the season from April 1 to April 3. Operations were suspended from April 9-12 and April 19-21 due to high river discharge and poor visibility. Normal operations resumed on April 22. On May 26, lift operations were delayed for repairs, and on May 28, operations were interrupted due to hazardous weather. The final lift for the shad passage season was on June 30. After this date, there were additional lift closures, but these are less relevant to the impact on shad passage.

Water temperatures during the 2022 fish passage season increased above 10 degrees C during mid-April and remained above that temperature through the rest of the month. The peak period of shad passage occurred during increases in water temperature occurring during the third week of May when daily mean water temperatures increased from 13.4°C to 19.2°C and May 21 and 22 when daily mean temperatures were at 18.4°C and 18.9°C, respectively (Figure 7.2; Normandeau 2022).

The number of American shad lifted upstream annually at the Holyoke Dam (Figure 7.3) has been highly variable through the time series, however 192,298 was below the long term mean of 308,000 and is the lowest annual lift value since 2011. During the last decade, the annual lift counts have experienced a general declined. Despite the recent general decline in lift counts, 3 of the 10 highest lift counts occurred during the last 10 years: 536,670 in 2017, 412,656 in 2013, and 385,930 in 2016.

For the 2022 biological sampling, there were 1,000 American shad collected for scale samples, representing 0.5% of the annual fish passage count. Scale samples were collected over 59 of the 72 lift days from April 26 through June 29. Samples were collected during 91% of the days when 65 days of shad passage occurred at the lift (Normandeau 2022).

The 2022 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 2022 weighted sex ratio of shad sampled at Holyoke was 49% male and 51% female. As is typical, the male fish are smaller in size than females.

Length frequency of American shad collected at the Holyoke lift in 2022 ranged from 325-475 mm FL for male shad and 343-521 mm FL among female shad. The average size among males was 396 mm FL and among females was 443 mm FL.

The preliminary 2022 examination of the adult shad population revealed that the age structure was primarily composed of fish from the 2015-2019 year classes. Among the male shad, the majority (64.6%) were five-year-old fish. Four-year-old fish made up 30.02% of the population, while six-year-old fish accounted for 4.76%. Three-year-old fish represented a minor portion, at 0.62%. Notably, there were no seven-year-old male fish.

In terms of the female shad sampled in 2022, most (66.6%) were five years old. Six-year-old fish contributed to 11.3% of the population, and four-year-old fish made up 21.9%. Seven-year-old fish were scarce, representing only 0.30% of the population.

The final QA/QC of the 2022 shad age structure and analysis of scale samples to determine the overall incidence of repeat spawning is still in progress.

**Juvenile Seine Survey**

The Connecticut River was sampled for juvenile alosines from July 21 to September 29, 2022. Over the course of the season, a total of 1,898 juvenile American shad were collected. The

highest catch of the year was recorded in mid-September at the Holyoke site, with 499 shad representing 26% of the total seasonal catch (see Table 7.2). The Holyoke site accounted for a significant portion of the annual catch, with a total of 1,558 shad, or 82% of the annual catch.

The catches at subsequent sites were as follows: Wilson (13.86%), Salmon River (3.85%), Deep River (0.11%), and Essex (0.11%). The geometric mean catch per unit effort value for American shad in 2022 was 3.93. This value ranks 34th out of 45 when ordered from highest to lowest, indicating a weak year class in the time series (Table 7.5).

The challenge of sampling in fixed-site nearshore areas has increased due to a combination of factors. The changes to the river bottom, characterized by silt and mud, pose a significant challenge to the sampling process. This issue is further exacerbated by the infestation of the invasive aquatic plant, *Hydrilla verticillata*.

The efficiency of the hand-hauled seine gear, a critical tool in our sampling process, is also impacted by several physical challenges. These include bank erosion and fallen trees, which are physical barriers to the gear. Increased siltation affects the mobility of the gear. Increasing densities of aquatic vegetation can entangle the gear, hindering its functionality. These challenges highlight the need for adaptive strategies and alternative solutions to ensure the efficiency of future survey sampling processes.

In 2022, a total of 51 seine hauls were completed, resulting in the collection of over 45,000 fish. These fish represented 34 different species or taxonomic groups (Table 7.6). To ensure minimal mortality and expedite the process of returning large catches to the water, certain fish were identified only at the family or genus level. This included species such as shiners, sunfish, catfish, and killifish. For common species that were caught in large numbers, visual counts were used to estimate their quantity. This approach helped to reduce handling and processing time. Blueback herring were found at the stations in Deep River and Essex, CT, with a total count of 4,570 fish. Menhaden were predominantly found in the lower river stations, with a total count of 18,401 fish (Table 7.4). The five most abundant species or groups collected in 2022 were menhaden, shiners, blueback herring, American shad, and sunfish (Tables 7.3-7.6).

**Additional Activies:**

*Interstate fisheries management accomplishments*

During this project segment the ASMFC benchmark coast wide stock assessment data update for Connecticut's river herring stocks was submitted. The CT River portion of the river herring stock assessment includes fisheries independent time series data.

**MODIFICATIONS**

Because of the continued staffing constraints for alosine work, CT DEEP is continuing to evaluate the extent of alosine monitoring that can be realistically maintained. The situation is further complicated by challenges related to sampling, from changes in land cover and the spread of invasive aquatic vegetation near the shore. These factors necessitate a critical evaluation of the effectiveness of the seine gear currently used in the CT River juvenile alosine survey.

The Atlantic States Marine Fisheries Commission Benchmark Stock Assessment of American Shad recommends the use of otolith ages as the preferred method for determining age. However, the extraction of otoliths necessitates the sacrifice of the fish, and it remains unclear when CT DEEP will be able to secure a sufficient number of shad otolith samples. The processing and imaging of otoliths would demand additional time and personnel resources. One of the benefits of using scales for aging is that they can reveal any prior spawning history of the fish. However, processing and examining both scales and otoliths would double the current workload, which is already unmanageable. Until there is an increase in staffing, current staff do not have the capacity to process both scales and otoliths.

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Table 7.1. Annual American shad commercial fishery harvest. Landings are reported by weight (lbs.) and by sex, 2009-2022.

| 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 |
| 2022 | 15,826 | 2,107 | 13,719 |

Table 7.2 Seine Survey catch and effort for CT River juvenile American shad, 2022.

| Date | Holyoke | Wilson | Salmon River | Deep River | Essex | Catch | Effort |
|---|---|---|---|---|---|---|---|
| 7/14/2022 | 0 | 0 | 1 | 1 | 1 | 3 | 5 |
| 7/21/2022 | 74 | 3 | 28 | 0 | | 105 | 4 |
| 7/28/2022 | 282 | 0 | 4 | 0 | 0 | 286 | 5 |
| 8/4/2022 | 3 | 0 | 19 | 0 | 0 | 22 | 5 |
| 8/10/2022 | 18 | 2 | 9 | 0 | 0 | 29 | 5 |
| 8/18/2022 | 41 | 86 | 2 | 0 | | 129 | 4 |
| 8/25/2022 | 1 | 3 | 4 | 0 | 0 | 8 | 5 |
| 9/1/2022 | 17 | 91 | 2 | 0 | 1 | 111 | 5 |
| 9/8/2022 | 275 | 2 | 2 | 0 | | 279 | 4 |
| 9/15/2022 | 499 | | 2 | 0 | | 501 | 3 |
| 9/22/2022 | 276 | | 0 | | | 276 | 2 |
| 9/29/2022 | 72 | 76 | 0 | 1 | | 149 | 4 |
| Total | 1558 | 263 | 73 | 2 | 2 | 1898 | 51 |

Table 7.3 Seine Survey catch and effort for CT River juvenile blueback herring, 2022.

| Date | Holyoke | Wilson | Salmon River | Deep River | Essex | Catch | Effort |
|---|---|---|---|---|---|---|---|
| 7/14/2022 | 0 | 0 | 12 | 58 | 3 | 73 | 5 |
| 7/21/2022 | 0 | 1 | 29 | 58 | | 88 | 4 |
| 7/28/2022 | 0 | 0 | 147 | 2 | 0 | 149 | 5 |
| 8/4/2022 | 0 | 0 | 974 | 0 | 0 | 974 | 5 |
| 8/10/2022 | 0 | 0 | 8 | 8 | 1 | 17 | 5 |
| 8/18/2022 | 0 | 0 | 671 | 31 | | 702 | 4 |
| 8/25/2022 | 0 | 0 | 42 | 6 | 0 | 48 | 5 |
| 9/1/2022 | 0 | 78 | 360 | 80 | 0 | 518 | 5 |
| 9/8/2022 | 0 | 0 | 480 | 567 | | 1047 | 4 |
| 9/15/2022 | 0 | 0 | 175 | 72 | | 247 | 3 |
| 9/22/2022 | 0 | 0 | 42 | 0 | | 42 | 2 |
| 9/29/2022 | 0 | 44 | 536 | 85 | | 665 | 4 |
| Total | 0 | 123 | 3476 | 967 | 4 | 4570 | 51 |

Table 7.4 Seine Survey catch and effort for CT River juvenile menhaden, 2022.

| Date | Holyoke | Wilson | Salmon River | Deep River | Essex | Catch | Effort |
|---|---|---|---|---|---|---|---|
| 7/14/2022 | 0 | 0 | 19 | 402 | 1 | 422 | 5 |
| 7/21/2022 | 0 | 0 | 7 | 1 | | 8 | 4 |
| 7/28/2022 | 0 | 0 | 0 | 122 | 0 | 122 | 5 |
| 8/4/2022 | 0 | 0 | 101 | 22 | 0 | 123 | 5 |
| 8/10/2022 | 0 | 0 | 39 | 5577 | 0 | 5616 | 5 |
| 8/18/2022 | 0 | 0 | 6 | 7 | | 13 | 4 |
| 8/25/2022 | 0 | 0 | 477 | 2242 | 0 | 2719 | 5 |
| 9/1/2022 | 0 | 0 | 960 | 171 | 1 | 1132 | 5 |
| 9/8/2022 | 0 | 0 | 376 | 5625 | | 6001 | 4 |
| 9/15/2022 | 0 | | 99 | 1780 | | 1879 | 3 |
| 9/22/2022 | 0 | | 41 | | | 41 | 2 |
| 9/29/2022 | 0 | 0 | 325 | 0 | | 325 | 4 |
| Total | 0 | 0 | 2450 | 15949 | 2 | 18401 | 51 |

Table 7.5 Geometric mean relative abundance index (CPUE) of juvenile American shad(ASD), 1978-2022.

| 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 |
| | | 2022 | 3.93 |

Table 7.6. List of fish species or group and percent frequency of occurrence of fish collected in Connecticut River seine survey, 2022.
**includes more than one species*

| Species or Group | % abundance | Species or Group | % abundance |
|---|---|---|---|
| Alewife | 0.05 | Golden Shiner | 0.10 |
| American Eel | 0.01 | Hogchoker | 0.07 |
| American Shad | 3.99 | Killifish & Mummichog* | 1.60 |
| Atlantic Needlefish | 0.01 | Largemouth Bass | 0.11 |
| Atlantic Silverside | 0.86 | Menhaden | 40.24 |
| Bay Anchovy | 0.05 | Northern Kingfish | 0.01 |
| Black Crappie | 0.19 | Northern Pike | <0.01 |
| Blue Crab | 0.03 | Pipefish | 0.01 |
| Blueback Herring | 9.61 | Rock Bass | 0.08 |
| Bluefish | 0.01 | Shiner* | 36.32 |
| Bowfin | 0.01 | Smallmouth Bass | 0.35 |
| Carp | 0.02 | Striped Bass | <0.01 |
| Catfish* | 0.01 | Sunfish* | 2.58 |
| Chain Pickerel | 0.01 | Tessellated Darter | 0.81 |
| Crayfish* | 0.01 | White Perch | 0.22 |
| Fallfish | 0.09 | White Sucker | 1.60 |
| Gizzard Shad | <0.01 | Yellow Perch | 0.94 |

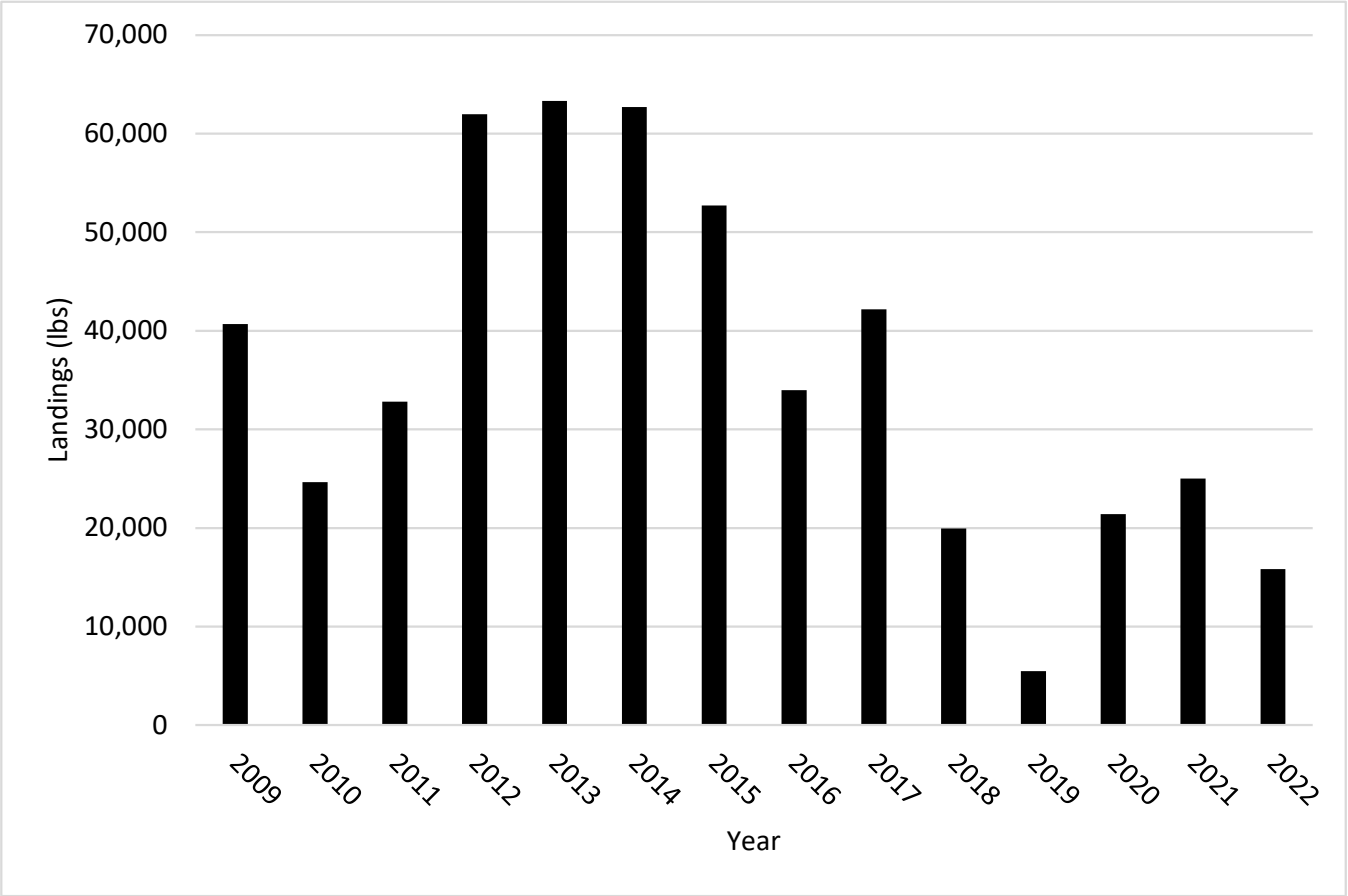

Figure 7.1. Commercial Landings (lbs) for CT River adult American shad, 2009-2022.

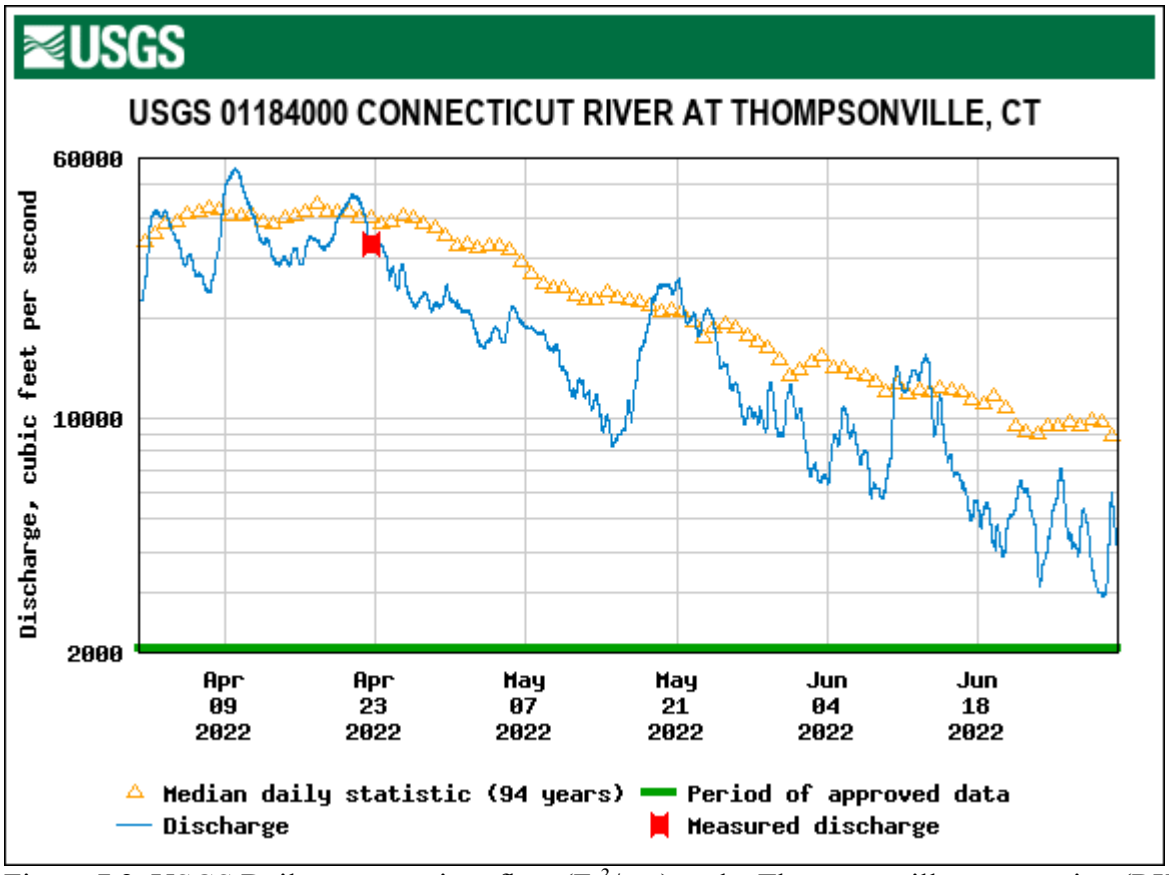


Figure 7.2 USGS Daily average river flow ($Ft^3$/sec) at the Thompsonville gage station (RKM 110) compared to median flows, during 2022 American Shad passage.

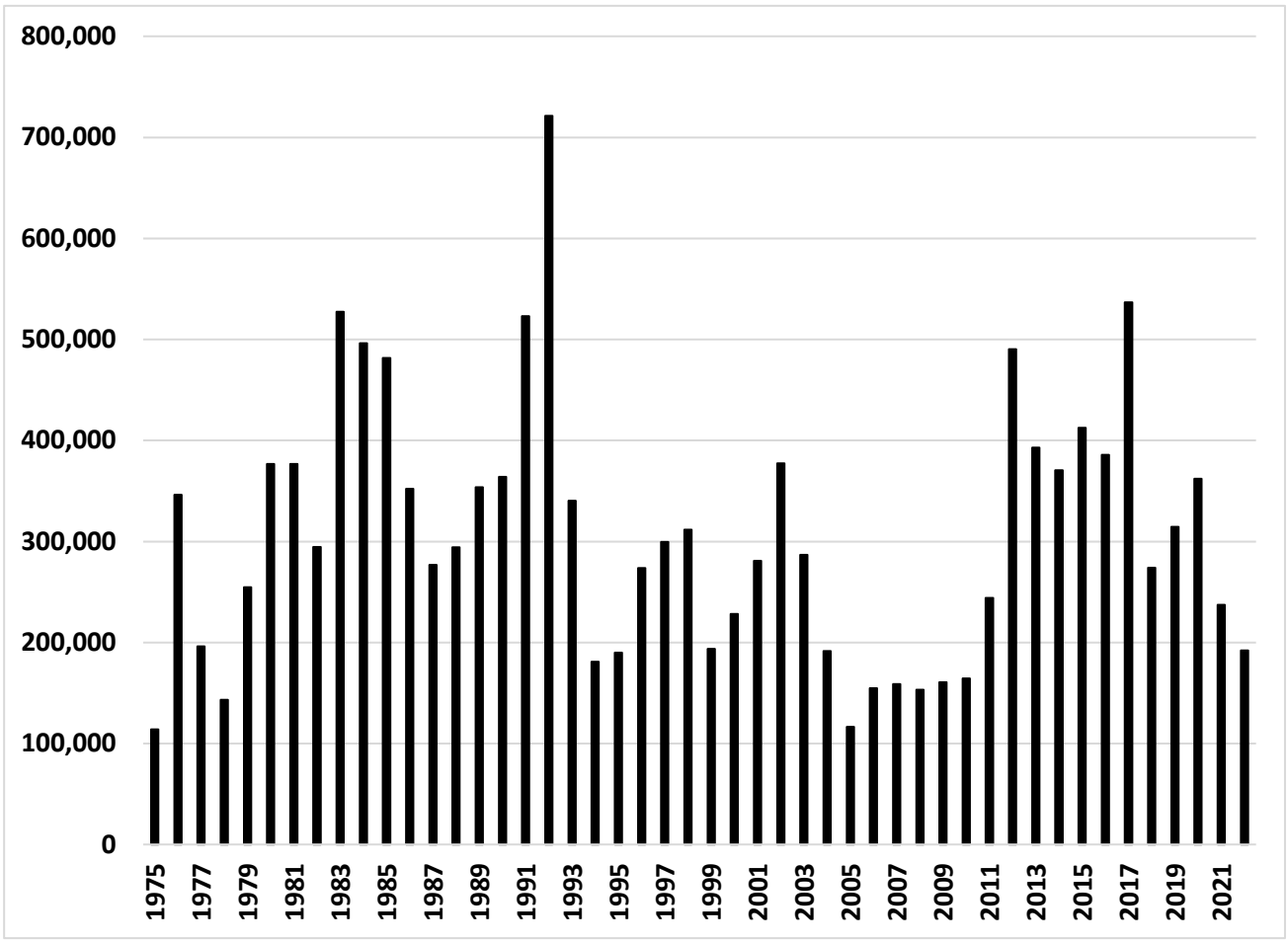

Figure 7.3 Number of adult American Shad lifted at the Connecticut River Holyoke Dam (RKM 139), 1975-2022

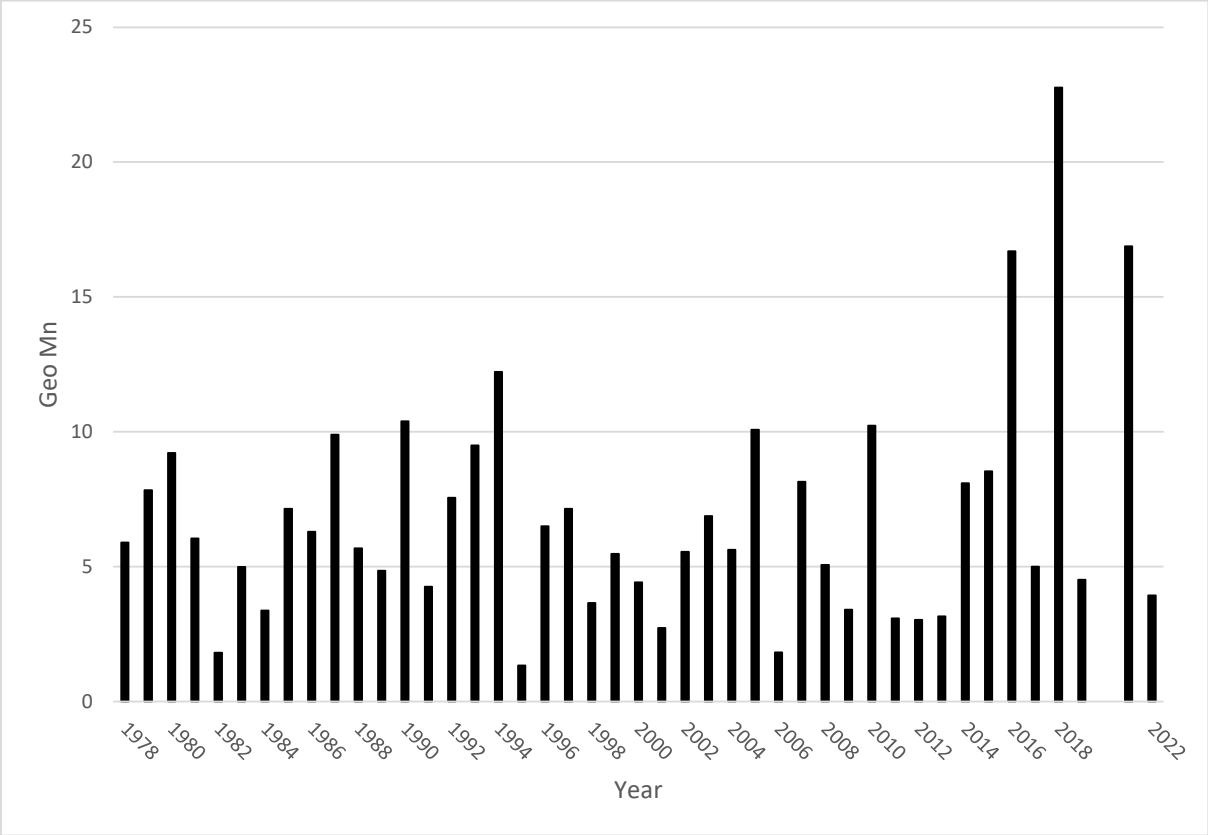

Figure 7.4 Annual geometric mean catch per unit effort of Connecticut River juvenile American shad by station,1978-2022. An index was not calculated in 2020 due to low sample size.

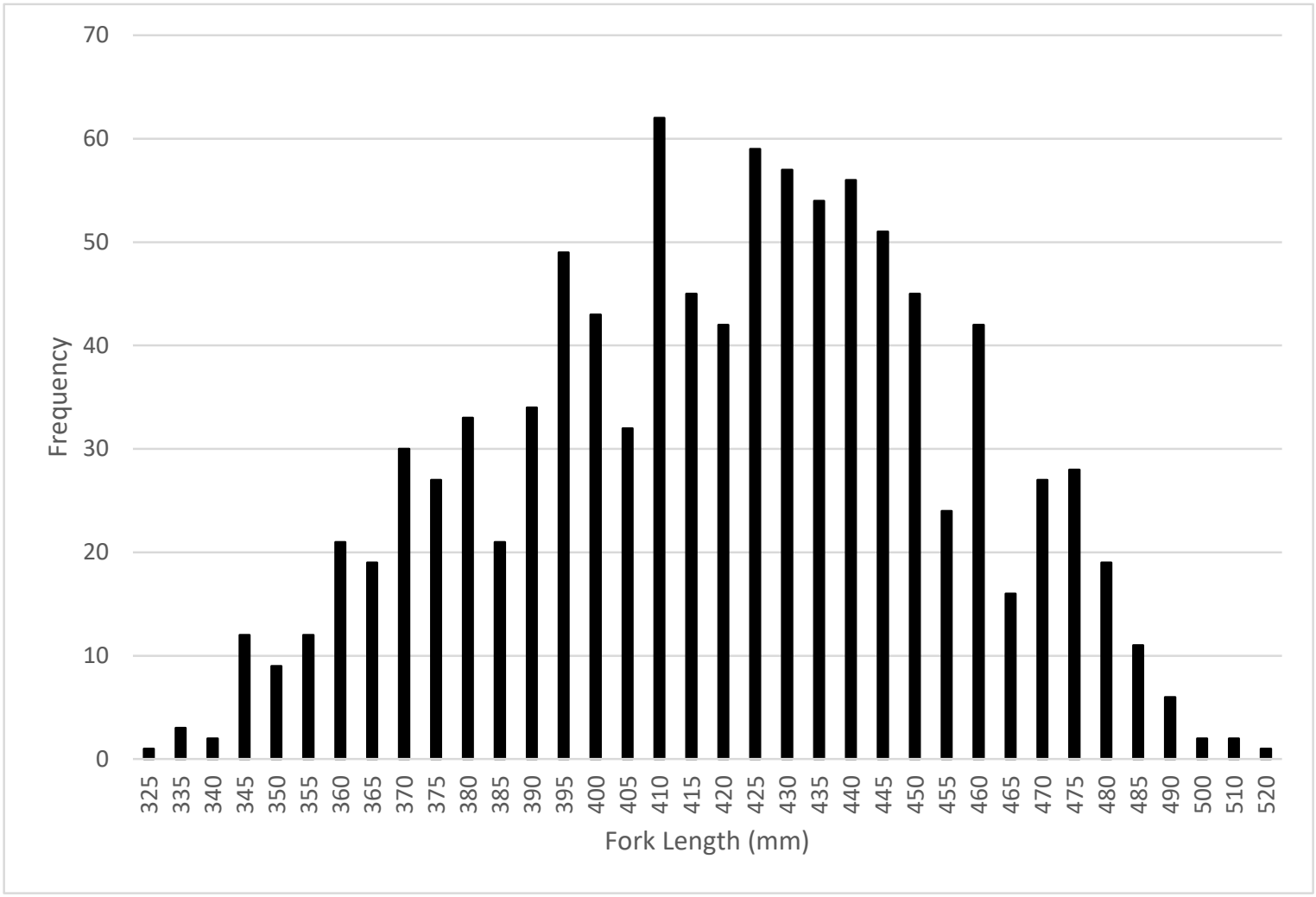

Figure 7.5. Length frequency (mm) of American shad, sampled from the Holyoke Lift,2022.