FINAL REPORT

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Grant Title: **NEW HAMPSHIRE'S MARINE FISHERIES INVESTIGATIONS**

Project I: **DIADROMOUS FISH INVESTIGATIONS**

Job 1: **ANADROMOUS ALOSID RESTORATION AND EVALUATION**

Objective: To restore anadromous alosids to a level of abundance that will enable them to fully utilize historical spawning habitat in the coastal rivers of New Hampshire.

Period Covered: January 1, 2019 - December 31, 2023

ABSTRACT

Between January 1, 2019 and December 31, 2023, the NH Fish and Game Department conducted one investigation per year to restore anadromous alosines to a level of abundance that will enable them to fully utilize historical spawning habitat in the coastal rivers of New Hampshire. Seven fishways on six New Hampshire (NH) coastal rivers were operated each spring through the project period of 2019 through 2023 to facilitate the passage of river herring (Alewife *Alosa pseudoharengus* and Blueback Herring *Alosa aestivalis)*, American Shad *Alosa sapidissima*, and other diadromous fish over dams.

Estimated numbers of river herring using all coastal river fish ladders during the project period increased by approximately 70.5% from the previous five-year project period (2014-2018). Alewives dominated returns to the Cocheco and Lamprey rivers while the Oyster River generally had a slightly higher percentage of Blueback Herring returning. Whereas in the Exeter River, the majority was Alewives with exception of one year where the Blueback Herring

dominated the spawning run. The Oyster River continues to have low return numbers and exhibits signs that poor habitat conditions are inhibiting restoration efforts. The Winnicut River fishway is ineffective at passing river herring except under limited flows and an investigation to determine a solution is ongoing. Seventy-eight American Shad returned to NH fishways during the project period.

In an effort to enhance local spawning stocks, thousands of river herring were transferred from the NH coastal rivers to the Merrimack River drainage to assist in anadromous fish restoration efforts. During 2019-2023, 17,419 river herring were stocked in impoundments or lakes within the Great Bay Estuary drainage. The NH Fish and Game Department has continued to work with state and federal agencies and non-governmental organizations on various cooperative diadromous fish passage projects on coastal NH rivers.

INTRODUCTION

New Hampshire's coastal rivers once supported abundant runs of anadromous fish including river herring (Alewife *Alosa pseudoharengus* and Blueback Herring *A. aestivalis*) and American Shad *A. sapidissima* (Jackson 1944). These and other diadromous species had been denied access to historical, freshwater spawning and nursery habitat since the construction of dams during the nineteenth century textile boom in most New Hampshire (NH) coastal rivers. Restoration of diadromous fish populations began with construction of fishways from the late 1950's through the early 1970's by the New Hampshire Fish and Game Department (NHFG) in the Cocheco, Exeter, Oyster, Lamprey, Taylor, and Winnicut rivers. These fishways reopened acres of freshwater spawning and nursery habitat for river herring, American Shad, and other diadromous fish.

Thereafter, fishway modifications, improvements, and dam removals have occurred in NH coastal rivers. Fishway modifications have been conducted to improve efficiency to upstream passage for several reasons, such as improving older fishway designs and changing dam uses (e.g., hydroelectric development, municipal water withdrawals, etc.). In addition, upstream and downstream passage systems have been improved or added (Wiswall and Cocheco dams). Dam removals affecting diadromous species in NH coastal rivers started in earnest around 2004 with head-of-tide dams (Bellamy, Winnicut, and Exeter rivers) and further upstream dams (Lamprey and Bellamy rivers). Additionally, new fishways have been constructed (Winnicut, Salmon Falls, and Lamprey rivers) to allow fish passage through upstream obstructions.

River herring serve as a significant bait source for commercial and recreational fisheries, while American Shad are an important recreational fish. Unlike Atlantic Salmon *Salmo salar* and American Shad, whose populations were

eliminated by barriers, river herring only declined in numbers by utilizing the small area of freshwater at the base of dams during spring runoff for spawning.

The river herring runs have been monitored at NHFG fish ladders since initiation of restoration programs in the early 1970's. Estimates or actual counts of fish passed above the fishways, as well as biological data such as lengths, sex ratios, and age data, are available from previous studies under Federal Aid Projects F-36-R and F-50-R. Additionally, river herring have been trapped and transported to various upriver locations for stock enhancement purposes since 1984.

Methods to restore river herring runs in other areas have been through stocking of Alewives (Rounsefell and Stringer 1945), construction of fishways (Collette and Klein-MacPhee 2002), or removal of defunct dams (Havey 1961). Some dam owners are required to provide fish passage and decisions must be made whether it is more appropriate to design and construct a fishway or to remove the dam. These options are often decided collaboratively with state and federal agencies.

The Atlantic States Marine Fisheries Commission's (ASMFC) Amendment 2 to the Interstate Fishery Management Plan for Shad and River Herring calls for states to close recreational and commercial river herring fisheries with an exception for systems with a sustainable fishery. In 2012, NH's River Herring Sustainable Fisheries Management Plan was approved by ASMFC and the plan was most recently updated in 2020. River herring in New Hampshire are currently managed as a statewide management unit. Two sustainability targets, one fishery-dependent and one fishery-independent, were established using exploitation rates and numbers of returning river herring per surface acre of available spawning habitat in the Great Bay Estuary. In 2020, NH failed to meet one of the sustainability targets, requiring closure of the river herring fishery in NH waters in 2021.

American Shad restoration began in 1972 with egg stocking that continued under Federal Project F-36-R from 1973-1978. This technique produced returns of fewer than a dozen American Shad per year. The purchase of circular transport tanks in the 1980's provided the opportunity to transport live, gravid adults to spawn in the coastal river systems. From 1980 to 1988, between 600 and 1,300 gravid adult American Shad were transported annually and distributed into the Exeter, Lamprey, and Cocheco rivers. In 1989, the decision was made to concentrate restoration efforts on one river at a time. The Exeter River was the river chosen for the American Shad restoration program due to the presence of two fish ladders that provided access to the greatest amount of habitat. Currently, the United States Fish and Wildlife Service (USFWS) has been actively stocking American Shad fry in the Lamprey River since 2018.

PROCEDURES

Seven fishways on six NH coastal rivers (Cocheco, Exeter, Lamprey, Oyster, Taylor, and Winnicut rivers) were operated from early April to early July, to allow for the passage of river herring, American Shad, and other diadromous fish to historical spawning and nursery areas. At all fishways except the Taylor, all fish passing through were enumerated by hand passing, daily time counts, or counts estimated by use of Smith-Root Model 1100/1101 or 1601 electronic fish counters. Numbers recorded by the electronic fish counters were adjusted by results of daily calibration consisting of a minimum of ten, one-minute time counts. During daily visits, fish ladders and electronic counting devices were examined to assure proper functioning. In 2015, the Atlantic States Marine Fisheries Commission's Shad and River Herring Management Board approved NHFG's request to discontinue the river herring monitoring requirement of the Taylor River due to returns diminishing to near zero. The Taylor River fishway is now operated as a swim through and not monitored daily.

The head-of-tide dam on the Winnicut River was removed in the fall of 2009 and a pool-and-weir fish passage was constructed at a channel constriction under a bridge in the fall of 2011. Daily time counts began in 2012 and were conducted at the uppermost section of the fish passage for ten one-minute intervals, to estimate the number of river herring able to navigate the pool-and-weir fishway.

After removal of the Great Dam in Exeter during the summer of 2016, the next upstream dam and associated fishway (Pickpocket Dam) was used as the primary monitoring site for returning diadromous fish until 2020. Beginning in 2021, quantitative monitoring of river herring occurs at the former Great Dam site, by conducting three 10-minute time counts daily throughout the fish migration period. The daily average of the time counts is expanded over the course of a twelve-hour migration period. Daily totals are summed to estimate annual river herring passage.

The fishway at Wiswall Dam on the Lamprey River is operated and maintained by the Town of Durham, NH, with technical assistance and monitoring provided as needed by NHFG. Annually, NHFG installs an electronic fish counter to estimate the number of river herring passing at the Wiswall Dam fishway.

In a cooperative effort with the Maine Department of Marine Resources and Green Mountain Power, an electronic fish counter was installed and monitored by NHFG at the head-of-tide Salmon Falls River fish passage in South Berwick, ME. This border river is typically monitored every three to five years to assess the spawning run and fish passage operation. Currently, the three Salmon Falls River hydroelectric projects above the head-of-tide are undergoing relicensing,

so the fishway has been monitored each year since 2017 to have accurate fish counts passing at the head-of-tide fishway throughout the relicensing process.

Attempts are made to collect biological samples consisting of length measurements, sex determination, and scale samples used for age determination from river herring and American Shad at the five monitored rivers each year. Separate biological samples from river herring were targeted for collection at the beginning, middle, and end of the spawning runs of each river. Each river's sample consisted of up to 150 random total length measurements (mm), species identifications, and sex determinations. In addition to collecting lengths, five scale samples were attempted to be taken from each centimeter increment, or "BIN", from each sex and species from each river (e.g., five scale samples for male Blueback Herring in the Oyster River between 25.0 cm and 25.9 cm, etc.). All American Shad encountered were sampled unless the fish showed signs of stress due to elevated water temperatures.

Scale samples were cleaned, mounted between glass slides, and aged using an overhead scale projector via methods described by Marcy (1969) for river herring and Cating (1953) for American Shad. In addition, river herring scale images were independently aged by a second reader using a QImaging microscopy camera and Image-Pro software. Scale samples were also used to confirm the species determination for river herring, either Alewife or Blueback Herring, using methods described by MacLellan et al. (1981).

NHFG and the USFWS continued a cooperative trap and transport program to enhance river herring runs in NH rivrs. During the spawning run, river herring were collected from coastal fishways and transported to impoundments or lakes in NH coastal and Merrimack River watersheds. Out-of-basin transfers of river herring are limited to 10% of the previous year's spawning run from the source river.

Additional anadromous fish restoration activities included NHFG working with dam owners, state and federal agencies, and non-governmental organizations to remove ageing dams and implement fish passage projects. The assistance included site reviews, consultation on the types of fishways or extent of dam decommissioning, project reviews, administrative assistance, interviewing of consultants, obtaining necessary permits, public education, and attendance at various public meetings.

RESULTS

Between January 1, 2019 and December 31, 2023, the NH Fish and Game Department conducted one investigation per year to restore anadromous alosines to a level of abundance that will enable them to fully utilize historical spawning habitat in the coastal rivers of New Hampshire. Numbers of spawning

adult river herring utilizing NH coastal fishways ranged from 41,363 to 366,237 and averaged 208,522 fish annually during the project period (Table 1.1-1). Overall, river herring returns increased by approximately 70.5% from the last five-year period, rising from 611,429 fish to 1,042,611. Strong returns to the Exeter River contributed to the increase. The return of 273,228 fish to the Exeter River in 2022 was the highest return recorded for that river.

Table 1.1-2 depicts the age structure of returning river herring within each river over time and Appendix Table 1.1-1 provides mean length at age for each year of the project period. Generally age-4 and age-5 fish comprised the largest percentage of fish returning to each river annually. The exception being the Lamprey River, which beginning in 2019 was largely comprised of age-5 and age-6 fish. Most rivers had only a small percentage of age-7+ fish returning; however, they comprised the majority of the sampled spawning population in the Cocheco River for 2018 and 2020 and showed as strong year classes in 2022 and 2023.

A summary of biological data collected from samples of river herring migrating through all the fishways is presented in Table 1.1-3. With just a few exceptions males dominated biological samples in all rivers in all years. Females had a larger mean length than males in all sampled locations in all years of the project period. Alewives accounted for the majority of the run to the Lamprey and Cocheco rivers and to the Exeter in four of the five years of the project period. Blueback Herring were the slight majority in the Oyster River in three of the five years of the project period.

During the 2019-2023 project period, approximately 17,169 river herring were transferred to NH coastal rivers via stocking trucks from the head-of-tide fishways to enhance local spawning runs (Table 1.1-4). In addition, there were several out-of-basin transfers from the Lamprey River to Winnisquam Lake, Potanipo Lake, Piscataquog River, Nashua River, Bellamy River, and the Winnicut River (Appendix Table 1.1-2). All out-of-basin locations stocked were within the Merrimack River watershed with the exception of the Bellamy and Winnicut rivers.

Seventy-eight American Shad returned to the Lamprey River in only one year of the project period (Table 1.1-5).

Various cooperative anadromous fish passage projects occurred during the project period. NHFG staff worked with other state, federal, and local partners on dam removal projects on the Oyster River (Mill Pond Dam), Durham, NH, and on the Cocheco River (Gonic dams), Rochester, NH.

DISCUSSION

During this five-year project period, NH’s annual migrations of river

herring increased by 431,182 fish from the previous five-year period between 2014 through 2018 (Table 1.1-1). The 70.53% increase may be a result of more favorable spring flow conditions and an increase returns to the Exeter and Oyster Rivers.

During the 2019-2023 time period, the total number of migrating river herring using the Cocheco River fishway decreased drastically by 229,108 fish from the previous five-year period (Table 1.1-1). The average annual return decreased from 49,467 fish per year to 3,645. One reason for the drastic decrease may be due to flow conditions, equipment failures, and ineffective fishway modifications.

Modifications made to the Cocheco River fishway trap conducted in the summer of 2015 allowed for the use of an electronic fish counter for the first time in 2016. This eliminated the laborious task, of netting and manually passing the entire anadromous fish run by NHFG staff. The unimpeded passage of fish through the single counting tube also allowed for constant movement of fish through the entire length of the fishway. However, following the low return in 2019, it was determined it would be best to operate the fishway as a trap and hand count fish until fish start returning at a higher rate requiring a fish counter. Following another low return in 2020, NHFG consulted with US Fish and Wildlife Service fish passage engineers regarding potential changes in operation for the 2021 season. These changes consisted of removing the two uppermost baffles within the fish trap to lower trap levels, provide more resilience to varying impoundment levels, and provide more flow and attraction water through the fishway. After low returns again in 2021, it was decided to remove all the previously revised structures within the fish trap reverting to operation using the fish counter.

In 2022, the fishway was operated as it was prior to 2016 and experienced a return of 4,452 river herring (Table 1.1-1). It is possible that the numbers of returning river herring in the Cocheco River will continue to increase in the coming years in response to reverting the fishway back to the former manner of operation.

Age-6 fish dominated the percent returns to the Cocheco River in two of the five years of the project period (Table 1.1-2). Age-7+ fish dominated the returns in 2020 accounting for 56.1% of the return. The strong returns of age-4 and age-5 fish in 2022 and 2023 indicates strong recruitment of the 2017-2019 year-classes. This may represent good conditions for in-river survival and viable emigration passage of juvenile river herring during those years.

Historically, there has been a goal to stock approximately 500 gravid river herring each to Bow Lake at the upper reaches of the Cocheco River system and to the impounded area above the second dam (Watson Dam). The practice of

placing pre-spawned river herring in inaccessible reaches of river systems due to barriers allows use of available spawning habitat to returning river herring, helps supplement constricted habitat, and augments declining runs in other watersheds. During the project period, inconsistency of the run made it difficult to collect fish to transfer from the Cocheco River fishway. However, each year transfers of river herring from the Lamprey River to Bow Lake were conducted (Appendix Table 1.1-2).

The Great Dam and associated fishway on the Exeter River were removed during the summer of 2016. The ASMFC's Interstate American Shad and River Herring Fishery Management Plan requires NHFG to continue monitoring the Exeter River despite removal of Great Dam. Fish have been monitored and enumerated at the Pickpocket Dam fishway since 2017. With only 17 river herring passing through the Pickpocket fishway in 2020, it was determined that numbers of river herring reaching the Pickpocket Dam fishway was not providing an accurate reflection of fish migrating past the former Great Dam location. Therefore, enumerating fish at the former Great Dam location would provide a better estimation of returns to the Exeter River. Beginning in 2021, three 10-minute time counts occurred daily throughout the fish migration. River herring passage during the project period in the Exeter River was estimated at 675,621 fish (Table 1.1-1), considerably above the prior project period.

Modifications to the Pickpocket Dam fishway were made during fall 2017 to allow operation as a trap and allow biological sampling. Sampling revealed the Exeter River run to be largely age-5 and age-6 fish during the project period (1.1-2). During three years of the project period Alewives dominated the fish sampled while the remaining two years was comprised of a mix of Alewives and Blueback Herring (Table 1.1-3). This is likely due to the location of the collection of fish samples. Beginning in 2021 fish were no longer sampled at the Pickpocket fishway but rather obtained through cast netting at the former Great Dam site. It is unknown why river herring are not reaching Pickpocket Dam fishway in greater quantities considering the passage estimates at the former Great Dam location.

The river herring returns to the Oyster River had historically been one of the highest yearly returns of all six rivers. The 1999 through 2003 project period had more fish migrated up the Oyster River than any other river with more than 335,000 river herring negotiating the fishway (Table 1.1-1). During the project period, 39,808 river herring utilized the Oyster River fishway, an increase from the prior five-year project period. The annual average of just 7,962 fish during the project period is far below the average of 37,390 fish per year over the 48-year time series. This continues the general decline in return numbers that began around 1993. The declining trend was likely

exacerbated by high flows that occurred during 2005, 2006, and 2007. Unlike other rivers that appear to be rebounding in numbers of returns after these high flow years, the Oyster River river herring returns continue to decline. One reason for the decline could be poor water quality affecting survival of young-of-year river herring in the impoundment due to low dissolved oxygen at periods of low flow which prevent downstream passage over the dam. Unpublished data acquired by the University of New Hampshire in the fall of 2005, showed hypoxic conditions in the impounded reaches of the Oyster River (Brian Smith, personal communication). In addition, the Oyster River impoundment is listed by NH Department of Environmental Services as a 303(d) threatened or impaired water body for dissolved oxygen.

Sampling revealed the Oyster River run to be dominated by age-4 and age-5 fish during the project period (1.1-2) and Blueback Herring generally constituted the majority of the Oyster River run in three of the five years (Table 1.1-3).

The Lamprey River return of 308,961 fish was the second highest return of all coastal NH Rivers during the project period (Table 1.1-1). The return of river herring at the Lamprey River decreased slightly by 24,918 fish over the prior project period. One of the contributors to the lower return during the project period was the low return of 34,684 fish in 2019.

In general, the Lamprey River has had an increasing trend since 1997 and several factors have likely been attributed to that, such as the enhancement stocking into Pawtuckaway Lake that occurs during most years. Pawtuckaway Lake is an impoundment in the upper reaches of the Lamprey River watershed where stocked gravid river herring can utilize inaccessible spawning and nursery habitat. Another factor contributing to increased returns could be good water quality resulting from the upper reaches of the Lamprey system being more rural and less inhabited than other monitored river systems and further protection on designated reaches through the Wild and Scenic Rivers National Program.

Additional fish passage opportunities have also been developed at upstream barriers in the Lamprey River system, including removal of a dam in Epping, NH, and construction of a Denil fish ladder in 2012 at the Wiswall Dam, which is the second passage barrier on the Lamprey River. The Wiswall Dam fish ladder has been operated since 2012 by the Town of Durham with technical guidance and monitoring provided by the NHFG.

In an effort to allow river herring to spawn further up in the Lamprey River watershed 7,440 river herring were transported and stocked in-basin at Pawtuckaway Lake (Table 1.1-4). In a continuing focused restoration effort between state and federal agencies fish from the Lamprey River were stocked to several different water bodies within the Merrimack River system (Appendix Table

1.1-2). The number of fish stocked out-of-basin annually does not exceed 10% of the prior years' fishway returns.

Due to a severely diminished spawning run and lack of a sampling trap at the Taylor River, the NHFG decided to discontinue daily monitoring in 2015. Eutrophication of the impoundment compounded by high flow years in 2005, 2006, and 2007 are likely the main reasons for the decline of the Taylor River's river herring population. Since 2015, the Taylor River fish ladder was opened to allow for diadromous fish passage, but was only monitored on a weekly basis. Daily monitoring activities will not be continued until further evidence of a river herring spawning run is observed.

The modified pool-and-weir fishway constructed in 2012 on the Winnicut River was monitored daily during the project period for river herring passage. There is no trap to enumerate returns so daily time counts are performed. Only five fish were observed passing through the Winnicut River fishway from 2019-2023. Returns at the former fishway/dam structure had averaged approximately 7,000 fish for the years 2007 through 2009. Each year since 2012, river herring have been observed in small quantities below the fishway, but are rarely observed within the upper pools of the fishway. It has been determined that a velocity barrier to river herring may exist within the fishway during the majority of spring flows. A solution to the problem is currently being explored. During the project period a small number of fish were captured via cast net and sampled. The sample was dominated by age-4 fish (Table 1.1-2) and consisted mostly of male Bluebacks (Table 1.1-3).

During the project period 78 American Shad returned to NH Coastal Rivers (Table 1.1-5). The recent increase in American Shad returns is largely due to efforts by the USFWS stocking of fry in the Lamprey River starting in 2018. While most American Shad return to their natal rivers to spawn there is also a small percentage that stray to nearby non-natal river systems (Mansueti and Kolb 1953; Williams and Daborn 1984; Melvin et al. 1985).

In summary, the total number of river herring using the coastal fishways increased during this project period by 431,182 fish from the previous five-year period (2014-2018). Increases in returning fish were seen in Exeter and Oyster rivers. The Cocheco, Lamprey, and Taylor rivers all saw decreases. Despite the high returns in some rivers there were still below average returns in the Oyster River, extremely low returns to the Cocheco River, and a lack of full access to freshwater habitat in the Winnicut River. The Oyster River saw its highest returns since 2010, but continues to exhibit signs that the spawning population is in a general decline since 1993. Alewives dominated returns to the Cocheco and Lamprey Rivers while the Oyster River was generally comprised of a slightly higher proportion of Bluebacks. River herring returns sampled at

the Exeter River were primarily Alewives. To assist in regional anadromous fish restorations efforts, thousands of river herring from NH coastal rivers were stocked into the Merrimack River drainage. Finally, NHFG has continued to work with state and federal agencies and non-governmental organizations in initiating dam removals or enhancing fish passage options at dams in coastal NH rivers in order to increase and improve diadromous fish access to viable spawning and rearing habitat.

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Table 1.1-1. Numbers of river herring returning to fishways on coastal rivers of New Hampshire, 1972–2023.

Year	Cocheco River	Exeter River	Oyster River	Lamprey River	Taylor River	Winnicut River	Annual total	5-year totals
1972				2,528		+	2,528	
1973				1,380		+	1,380	
1974				1,627		+	1,627	
1975		2,639		2,882		+	5,521	
1976	9,500		11,777	3,951	450,000	+	475,228	
1977	29,500		359	11,256		2,700++	43,815	
1978	1,925	205	419	20,461	168,256	3,229++	194,495	
1979	586	186	496	23,747	375,302	3,410++	403,727	
1980	7,713	2,516	2,921	26,512	205,420	4,393++	249,475	
1981	6,559	15,626	5,099	50,226	94,060	2,316++	173,886	
1982	4,129	542	6,563	66,189	126,182	2,500++	206,105	
1983	968	1	8,866	54,546	151,100	+	215,481	
1984	477		5,179	40,213	45,600	+	91,469	
1985	974		4,116	54,365	108,201	+	167,656	
1986	2,612	1,125	93,024	46,623	117,000	1,000++	261,384	
1987	3,557	220	57,745	45,895	63,514	+	170,931	
1988	3,915		73,866	31,897	30,297	+	139,975	
1989	18,455		38,925	26,149	41,395	+	124,924	
1990	31,697		154,588	25,457	27,210	+	238,952	
1991	25,753	313	151,975	29,871	46,392	+	254,304	
1992	72,491	537	157,024	16,511	49,108	+	295,671	
1993	40,372	278	73,788	25,289	84,859	+	224,586	
1994	33,140	*	91,974	14,119	42,164	+	181,397	
1995	79,385	592	82,895	15,904	14,757	+	193,533	
1996	32,767	248	82,362	11,200	10,113	+	136,690	
1997	31,182	1,302	57,920	22,236	20,420	+	133,060	
1998	25,277	392	85,116	15,947	11,979	219	138,930	
1999	16,679	2,821	88,063	20,067	25,197	305	153,132	
2000	30,938	533	70,873	25,678	44,010	528	172,560	
2001	46,590	6,703	66,989	39,330	7,065	1,118	167,795	882,530
2002	62,472	3,341	58,179	58,065	5,829	7,041	194,927	
2003	71,199	71	51,536	64,486	1,397	5,427	194,116	
2004	47,934	83	52,934	66,333	1,055	8,044	176,383	
2005	16,446	66	12,882	40,026	233	2,703	72,356	
2006	4,318	16	6,035	23,471	147	822	34,809	477,023
2007	15,815	40	17,421	55,225	217**	7,543	96,261	
2008	30,686	168	20,780	36,247	976	8,359	97,214	
2009	36,165	513	11,661	42,425	*	4,974	95,737	
2010	32,654	69	19,006	33,327	675	576+++	86,307	
2011	43,090	256	4,755	50,447	59	72+++	99,338	503,862
2012	27,608	378	2,573	86,862	92	5+++	117,518	
2013	18,337	588	7,149	79,408	128	0	105,610	
2014	29,968	789	4,227	84,868	57	0	119,909	
2015	64,456	5,562	1,803	69,843	*	0	141,664	
2016	99,241	6,622	863	92,364	*	0	199,090	611,429
2017	28,926	*** ^	4,492	35,920	*	0	69,338	
2018	24,743	32^	5,716	50,884	*	53+++	81,428	
2019	1,682	28^	4,969	34,684	*	0	41,363	
2020	3,832	17^	4,655	56,632	*	0	65,126	
2021	2,117	167,400^^	9,976	80,567	*	5	260,065	1,042,611
2022	4,452	273,228^^	11,272	77,285	*	0	366,237	
2023	6,143	234,948^^	8,936	59,793	*	0	309,820	

* - Swim through operation
** -Due to fish counter malfunction there was up to two weeks where passing fish were not enumerated
*** - Sea lamprey inundation caused fish counter to false count
\+ - Fishway unable to pass fish until modifications in 1997
++ - Fish netted below and hand passed over Winnicut River dam
+++ - Minimum estimate based on time counts, fishway/dam removed in fall 2009
^ - Great Dam removed in summer 2016, fish now enumerated at Pickpocket Dam
^^ - Fish now enumerated though Time Counts at former Great Dam site

Table 1.1-2. Weighted age composition of river herring spawning in coastal rivers of New Hampshire derived from scale samples, 2017–2023.

River	Year	Age (%)					N
		Age-3	Age-4	Age-5	Age-6	Age-7+	
Cocheco River	2017	0.1	2.5	24.5	57.2	15.7	70
	2018	0.0	11.5	12.6	14.2	61.7	90
	2019	1.0	19.2	20.0	31.5	28.3	123
	2020	0.0	5.5	15.9	22.6	56.1	102
	2021	0.5	20.6	20.5	35.5	22.8	124
	2022	0.0	30.3	36.6	15.3	16.6	91
	2023	0.6	55.9	28.1	12.6	2.7	97
Exeter River	2017	9.1	56.8	18.2	15.9	0.0	44
	2018	0.0	31.6	58.3	6.9	3.1	26
	2019	0.0	16.7	35.4	30.6	17.4	23
	2020	0.0	0.0	27.1	50.6	16.5	17
	2021	0.0	9.5	58.4	30.9	1.2	60
	2022	0.0	28.1	44.0	18.1	8.7	65
	2023	2.9	41.1	26.0	18.5	10.8	51
Oyster River	2017	6.3	74.4	16.1	2.9	0.4	108
	2018	3.8	44.4	35.6	14.6	1.6	121
	2019	2.4	24.4	41.1	23.4	8.4	108
	2020	1.0	21.7	34.5	24.9	18.0	128
	2021	0.0	31.6	51.5	16.4	0.4	112
	2022	0.6	31.4	48.5	15.3	4.2	113
	2023	0.2	40.4	29.4	27.5	2.5	128
Lamprey River	2017	0.0	10.3	14.6	51.7	23.4	76
	2018	0.0	49.2	26.8	8.1	16.0	86
	2019	0.0	16.7	33.9	37.6	11.8	77
	2020	0.0	5.5	45.9	39.1	9.5	77
	2021	0.0	13.2	41.8	29.7	15.2	74
	2022	0.0	6.3	42.2	35.4	16.1	76
	2023	0.0	9.7	36.9	33.6	19.9	71
Winnicut River	2017	No samples taken					
	2018	8.3	40.0	33.3	15.0	3.3	60
	2019	0.0	23.9	38.0	35.2	2.8	71
	2020	No samples taken					
	2021	No samples taken					
	2022	No samples taken					
	2023	No samples taken					

Table 1.1-3. Mean total length, percent sex composition, and percent species composition of river herring spawning runs at New Hampshire coastal fish ladders, 2019–2023.

River	Year	Mean length (cm)		%	%	N	%	%
		Male	Female	Male	Female		Alewife	Blueback
Cocheco	2019	28.4	29.5	51.1	48.9	123	65.0	35.0
	2020	28.6	29.8	46.0	54.0	102	97.5	2.5
	2021	27.6	28.8	56.2	43.8	124	72.4	27.6
	2022	27.6	28.9	55.5	44.5	91	90.3	9.8
	2023	27.3	28.4	58.4	41.6	97	97.2	2.8
Exeter	2019	28.5	29.6	46.4	53.6	23	100.0	0.0
	2020	29.5	28.4	64.7	35.3	17	100.0	0.0
	2021	27.6	28.6	52.1	45.7	60	97.8	2.2
	2022	26.9	27.9	78.0	22.0	65	30.5	69.5
	2023	26.8	28.2	66.2	33.8	51	62.5	37.5
Oyster	2019	27.0	28.2	57.6	42.4	108	35.9	64.1
	2020	25.7	28.0	63.9	36.1	128	36.0	64.0
	2021	25.9	26.6	53.2	46.8	112	5.2	94.8
	2022	26.7	28.0	54.3	45.7	113	50.7	49.3
	2023	27.0	28.3	60.2	39.8	128	61.6	38.4
Lamprey	2019	28.3	29.6	63.3	36.7	77	99.8	0.2
	2020	28.5	29.6	59.6	40.4	77	100.0	0.0
	2021	28.5	29.7	61.3	38.7	74	100.0	<0.1
	2022	29.0	30.2	52.1	47.9	76	100.0	0.0
	2023	29.6	30.5	57.4	42.6	71	100.0	0.0
Winnicut	2019	26.5	27.9	63.4	36.6	71	36.6	63.4
	2020	No samples taken						
	2021	No samples taken						
	2022	No samples taken						
	2023	No samples taken						

Table 1.1-4. Numbers of adult gravid river herring stocked in New Hampshire coastal rivers, 1985–2023.

Year	Cocheco River system	Winnicut River	Exeter River	Oyster River	Lamprey River system	Salmon Falls River
1985	500					
1986	2,000					
1987	2,125					
1988	2,000					
1989						
1990	2,000					
1991	1,700					
1992	1,300					
1993						
1994	365[a]				320[a]	220
1995	1,400[a]		125		3,230[b]	250
1996	750[a]				2,100[a]	200
1997	950[a]				2,000[a]	300
1998	1,000[a]	300			1,975[a]	240
1999	990[a]	200			2,020[a]	200
2000	1,000[a]	430			2,020[a]	320
2001	1,000[a]				2,000[a]	200
2002	1,000[a]				1,900[a]	
2003	1,100[a]				2,000[a]	
2004	1,050[a]		100		2,000[a]	
2005	1,000[a]		200		2,000[a]	
2006	1,000[a]		40		200[a]	
2007	900[a]		175		2,000[a]	
2008	1,000[a]		250		2,000[a]	
2009	500[a]		250		750[a]	
2010	1,000[a]				750[a]	
2011	2,000[a]	200	659		2,145[a]	
2012	1,000[a]				1,000[a]	
2013	480[a]					
2014						
2015	1,000[a]	250			1,500[a]	
2016	1,000[a]	250			1,000[a]	
2017		250			1,000[a]	
2018		250			1,000[a]	
2019					760[a]	
2020	600[a]	250	260	320[a]	1,050[a]	
2021	1,370	250	224	300[a]	1,600[a]	
2022	2,520	280	290	270	2,030[a]	
2023	2,575[b]			220[a]	2,000[a]	

[a] – In-river transfer

[b] – Combination of in-river and out-of-basin transfers

Table 1.1-5. American Shad returns to New Hampshire coastal fishways, 1983–2023.

Year	Exeter River	Lamprey River	Cocheco River	Oyster River
1983	0	0	3	0
1984	0	0	0	0
1985	0	2	1	0
1986	0	39	1	0
1987	0	0	0	0
1988	[b]	[b]	4	0
1989	[b]	[b]	8	0
1990	[b]	[b]	3	0
1991	12	2	6	0
1992	22	5	24	0
1993	21	200[a]	17	0
1994	[b]	13[a]	9	0
1995	18	14[a]	8	0
1996	58	2[a]	5	0
1997	30	4[a]	11	0
1998	33	3[a]	6	0
1999	129	3[a]	2	0
2000	163	7[a]	14	0
2001	42	6[a]	6	0
2002	41	4[a]	4	0
2003	33	26[a]	6	0
2004	22	33[a]	12	0
2005	3	12[a]	8	0
2006	2	6[a]	0	0
2007	0	4[a]	7	0
2008	0	4[a]	7	0
2009	7	4[a]	11	0
2010	0	5[a]	2	0
2011	2	1	6	0
2012	0	0	4	0
2013	0	0	1	0
2014	0	0	1	0
2015	0	0	1	0
2016	0	0	0	0
2017	[c]	0	0	1
2018	[c]	0	0	0
2019	[c]	0	0	0
2020	[c]	0	0	0
2021	[c]	0	0	0
2022	[c]	0	0	0
2023	[c]	78[a]	0	0

[a] - Minimum counts - ladder operated as swim through until late May or early June
[b] - No counts - ladder was operated as a swim through
[c] - No counts – Dam and associated fishway removed