

PROGRESS REPORT

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Approved By:   
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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, 2021 - December 31, 2021

ABSTRACT

Seven fishways on six New Hampshire (NH) coastal rivers were operated during the spring of 2021 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 passing through coastal river fish ladders in 2021 increased nearly fourfold from 2020. Alewives dominated spawning run returns to the Cocheco, Exeter, and Lamprey rivers while the Oyster River had a higher percentage of Blueback Herring returning. The Cocheco River had its second lowest return since 1985. The Oyster River had its highest return since 2010, but continues to exhibit signs that degraded impoundment habitat are inhibiting restoration efforts. In the absence of restoration efforts, no American Shad returned to NH fishways in 2021.

In an effort to enhance anadromous fish restoration efforts, thousands of river herring were transferred from the Lamprey River fish ladder to NH coastal rivers and lakes, and 3,750 to the Merrimack River 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 rivers in NH.

## INTRODUCTION

New Hampshire's coastal rivers once supported abundant runs of anadromous fish including river herring (Alewife *Alosa pseudoharengus* and Blueback Herring *Alosa aestivalis*) and American Shad *Alosa 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.

Since that time, 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 on older fishway designs and changing dam uses (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 fishing 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, but 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 there is no American Shad restoration effort, however residual American Shad spawning runs still remain.

#### 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 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) is the monitoring site for returning diadromous fish. 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 Wiswall.

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 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 Rollinsford hydroelectric project is undergoing relicensing, so we have monitored the fishway each year since 2017 to have accurate fish counts 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 U.S. Fish and Wildlife Service continued a cooperative trap and transport program to enhance river herring runs in NH rivers. 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

Estimated numbers of spawning adult river herring passing through the five monitored coastal rivers in 2021 ranged from five fish at the Winnicut River fishway to 167,400 fish in the Exeter River (Table 1.1-1). The total NH coastal river herring return was 260,065 fish in 2021. The earliest date fish were observed at a fish ladder was April 15 in the Lamprey River (Table 1.1-2). The spawning runs in the remaining rivers began on April 16, April 30, and May 5. Water temperatures during the peak of the spawning runs ranged between 15°C and 19°C.

A summary of biological data collected from samples of river herring migrating through all the fishways is presented in Table 1.1-3. Males dominated biological samples in all rivers. Females had a larger mean length than males in all rivers sampled. Alewives accounted for 100% of the run to the Exeter and Lamprey rivers and 72.4% in the Cocheco. Blueback Herring were the majority in the Oyster representing 94.8% of the return.

Tables 1.1-4 and 1.1-5 present results of age analysis of 370 river herring scale samples collected in 2021. Table 1.1-4 depicts the age structure

of returning river herring within each river since 2015 and Table 1.1-5 shows the length-at-age data obtained from the BIN sample method for 2021. Age-5 fish comprised the largest percentage returning to the Exeter, Oyster, and Lamprey rivers (Table 1.1-4). Age-6 fish dominated the Cocheco River returns. Mean lengths-at-age were generally larger in the Exeter and Lamprey rivers than in the Oyster and Cocheco rivers (Table 1.1-5).

In 2021, approximately 7,444 river herring were transferred via stocking trucks from the head-of-tide fishway on the Lamprey River to enhance the NH coastal and Merrimack River spawning runs (Table 1.1-6). There were six out-of-basin transfers in 2021 from the Lamprey River; 750 to Winnisquam Lake and 3,000 to Potanipo Lake within the Merrimack River watershed, 224 to Pickpocket Dam on the Exeter River, 250 to the Winnicut River, 1,370 to Bow Lake in the Cocheco River watershed, and 250 to the Bellamy River. The only in-river transfer of river herring in 2021 was 1,600 to Pawtuckaway Lake. Table 1.1-7 shows a complete list of river herring enhancement stockings in coastal rivers since 1985.

With the lack of concerted restoration efforts, only American Shad remnant runs remain in NH coastal rivers. In 2021, no American Shad returned to NH coastal rivers (Table 1.1-8).

Various cooperative anadromous fish passage projects occurred in 2021. NHFG staff has been working with other state, federal and local partners on dam removal projects in Durham on the Oyster River (Mill Pond Dam); Rochester, NH, on the Cocheco River (Gonic dams); and Sawyer Mill dams, Dover, NH, on the Bellamy River.

## DISCUSSION

Total estimated river herring returning to NH coastal rivers increased nearly fourfold from 65,126 in 2020 to 260,065 in 2021 (Table 1.1-1). The return in 2021 is the highest return seen since 1992 and is far above the long-term average through 2020 of 149,157 fish. The high coastal return in 2021 was driven by high returns to the Exeter and Lamprey rivers despite continuing below average returns in the Oyster and Cocheco rivers and inconsistent fish passage potential at the Winnicut River.

In 2021, the Cocheco River experienced a return of 2,117 river herring (Table 1.1-1). This was the second lowest return seen since 1985. The 2021 return was a decrease of approximately 45% from the return in 2020 and is considerably below the long-term average through 2020 of 27,038. The Cocheco River spawning run began on April 16<sup>th</sup> (Table 1.1-2), and consisted of 72.4% Alewives (Table 1.1-3). Cool water temperatures that persisted through mid-May may have contributed to the extremely low return. In addition, river flows

diminished throughout the migration season, resulting in a lower impoundment elevation during the 2021 migration season and less attraction flow into the fish ladder. This was compounded by daily varying pond elevation due to operation of the hydroelectric facility at the Cocheco Falls Dam. This severely affected the efficient operation of the fishway and likely negatively affected total upstream fish passage.

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 passing the entire anadromous fish run by hand 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 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 down the fishway. Finally, after low returns again in 2021 it was decided to remove all the structure within the fish trap allowing for fish counter use. In 2022, the fishway will be operated as it was prior to 2016.

Age-6 fish dominated the returns to the Cocheco River accounting for 35.5% of the spawning run (Table 1.1-4). Age-7+ and age-4 fish followed with 22.8% and 20.6%, respectively. In 2015, good conditions for in-river juvenile survival and viable emigration passage likely resulted in the strong year-class represented by the high percentage of age-6 fish.

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 that may lead to lower returns, and augments declining runs in other watersheds. In 2021, we were able to transfer 1,370 fish from the Lamprey River to Bow Lake (Table 1.1-6).

The Great Dam and associated fishway on the Exeter River were removed during the summer of 2016. New Hampshire Fish and Game is required to continue Atlantic States Marine Fisheries Commission's fishery management monitoring for 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 fishway was not providing an accurate reflection of fish passing 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. During 2021, three 10-minute time counts occurred daily throughout the fish migration. River herring passage during the 2021 migration season was estimated at 167,400 fish (Table 1.1-1). Biological samples for the Exeter River were obtained from the 329 river herring passed at the Pickpocket fishway in 2021. It is unknown why river herring are not reaching Pickpocket Dam in greater quantities considering the passage estimate at the former Great Dam location.

The Exeter River herring run started on May 5<sup>th</sup> (Table 1.1-2) and consisted of 100% alewives (Table 1.1-3). Age-5 fish dominated the return at 58.4% followed by age-6 fish at 30.9% (Table 1.1-4). In an effort to bolster the return of fish further up the watershed, 224 adult river herring were stocked from the Lamprey River to above the Pickpocket Dam (Table 1.1-6).

In 2021, the Oyster River had a return of 9,976 river herring (Table 1.1-1), far below the average of 39,212 fish over the prior time series. The return in 2021 was the highest seen since 2010, however there continues to be a general decline in return numbers that began around 1993. 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 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 the NH Department of Environmental Services as a 303(d) threatened or impaired water body for dissolved oxygen.

In an effort to place gravid adults into better quality spawning habitat, 300 river herring were stocked approximately 5.5 km upstream of the Town of Durham water supply dam in 2021. The water supply dam is the first barrier to river herring passage after ascending the fishway at Mill Pond Dam. The Town of Durham is currently exploring options to address deficiencies of the Mill Pond Dam that include repair, dredging, removal, or a combination of those options.

Blueback Herring constituted 94.8% of the run in the Oyster River (Table 1.1-3). In recent years, the river herring return was comprised of an even mix of Alewife and Blueback Herring. The high percentage of Blueback Herring in 2021 might indicate an improvement in the quality of the preferred riverine spawning habitat in the Oyster River. In March 2016, NHFG staff performed a field investigation to determine if any previous riverine spawning habitat is



now inaccessible to river herring or severely degraded. While a beaver dam was located, it was determined that the dam was low enough that during spring flows river herring likely could migrate upstream of the site.

The Lamprey River generally has one of the highest spawning runs of all coastal rivers each year (Table 1.1-1). The return of 80,567 in 2021 was far above the time series average return through 2020 of 37,420 and the highest return since 2016. The 2021 return consisted of 41.8% age-5 fish indicating 2016 was a good recruitment year (Table 1.1-4). Several factors have likely contributed to good returns to the Lamprey River; enhancement stocking into Pawtuckaway Lake, an upper watershed impoundment (Table 1.1-6); good water quality resulting from the upper reaches of the Lamprey system being more rural and less inhabited than other monitored coastal 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, including removal of a dam in Epping, NH, and construction of a Denil fish ladder in 2012 at the second mainstem dam, Wiswall Dam. The Wiswall Dam fish ladder has been operated during the spring migration since 2012 by the Town of Durham with technical guidance and monitoring provided by the NHFG. In 2021, the NHFG estimated 56,235 river herring migrated through the Wiswall Dam fishway, representing a passage of 69.7% of the total river herring that passed through the head-of-tide fish ladder of the Lamprey River system.

In a continued focused restoration effort between state and federal agencies, 3,000 and 750 fish from the Lamprey River were stocked in Potanipo Lake and Winnisquam Lake, respectively, within the Merrimack River watershed (Table 1.1-6) and 1,600 river herring were transported and stocked in-basin at Pawtuckaway Lake. In addition, 224 fish from the Lamprey River were stocked into the Exeter River, 250 to the Winnicut River, 1,370 to Bow Lake, and 250 to the Bellamy River.

Due to a severely diminished spawning run and lack of a sampling trap at the Taylor River, the NHFG has previously decided to discontinue daily monitoring. Eutrophication of the impoundment compounded by poor accessibility during high flow years in 2005, 2006, and 2007 are likely the main reasons for the decline of the Taylor River's river herring population. In 2021, 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 in 2021 for river herring passage. There is no trap

to enumerate returns so daily time counts are performed. Each year since 2012, river herring have been observed in small quantities in the lower pools and habitat below the fishway, but were never observed within the upper pools of the fishway until 2018. Although no fish were enumerated in 2021, fish were once again observed in 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.

In 2021, no American Shad returned to coastal fishways (Table 1.1-8). There are currently no adult American Shad restoration efforts occurring on the NH coast, so it is likely the few fish occasionally encountered are strays from other rivers. While most American Shad return to their natal rivers to spawn there is 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 estimated total number of river herring that passed through monitored NH coastal fish ladders in 2021 increased nearly fourfold from 2020 estimates. This is the highest return since 1992. Strong returns to the Exeter and Lamprey rivers contributed to the increased return in 2021. Despite the high returns in some rivers there were still below average returns in the Oyster River, an extremely low return to the Cocheco River, and a lack of full access to freshwater habitat in the Winnicut River in 2021. The Oyster River had its highest return since 2010 but continues to exhibit signs that the spawning population is in a general decline since 1993. Alewives accounted for 100% of the run to the Exeter and Lamprey rivers and 72.4% in the Cocheco. Blueback Herring were the majority in the Oyster River representing 94.8% of the return. To assist in regional anadromous fish restorations efforts, 3,750 river herring from the Lamprey River were stocked into the Merrimack River drainage. There were no American Shad that returned to coastal rivers in 2021. 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, 1972–2021.

Year	Cocheco River	Exeter River	Oyster River	Lamprey River	Taylor River	Winnicut River	Annual total
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 <sup>++</sup>	43,815
1978	1,925	205	419	20,461	168,256	3,229 <sup>++</sup>	194,495
1979	586	186	496	23,747	375,302	3,410 <sup>++</sup>	403,727
1980	7,713	2,516	2,921	26,512	205,420	4,393 <sup>++</sup>	249,475
1981	6,559	15,626	5,099	50,226	94,060	2,316 <sup>++</sup>	173,886
1982	4,129	542	6,563	66,189	126,182	2,500 <sup>++</sup>	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 <sup>++</sup>	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
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
2007	15,815	40	17,421	55,225	217 <sup>**</sup>	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 <sup>+++</sup>	86,307
2011	43,090	256	4,755	50,447	59	72 <sup>+++</sup>	99,338
2012	27,608	378	2,573	86,862	92	5 <sup>+++</sup>	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
2017	28,926	<sup>+++</sup>	4,492	35,920	*	0	69,338
2018	24,743	32	5,716	50,884	*	53 <sup>+++</sup>	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

\* 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.

Table 1.1-2. Summary data for river herring spawning runs for coastal rivers of New Hampshire, 2021.

River	River herring run		Temperature (°C)			Return (#'s)	Count method*
	Start	End	Min	Max	During peak of run		
Cocheco River	4/16/21	6/5/21	7	19	17	2,117	H
Exeter River	5/5/21	6/5/21	6	22	19	167,400	T
Oyster River	4/30/21	6/8/21	8	21	15	9,976	H
Lamprey River	4/15/21	6/10/21	6	25	15	80,567	H,E

\* H = hand count; E = electronic counter; T = time counts

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, 2021.

River	Mean length (cm)		%		%	
	Male	Female	Male	Female	Alewife	Blueback
Cocheco River	27.6	28.8	56.2	43.8	72.4	27.6
Exeter River	27.6	28.6	53.3	46.7	100.0	0.0
Oyster River	25.9	26.6	53.2	46.8	5.2	94.8
Lamprey River	28.5	29.7	61.3	38.7	100.0	<0.1

Table 1.1-4. Weighted age composition of river herring spawning in coastal rivers of New Hampshire derived from scale samples, 2015–2021.

River	Year	Age (%)					N
		Age-3	Age-4	Age-5	Age-6	Age-7+	
Cochecho River	2015	4.5	30.3	42	21.3	1.9	80
	2016	0.6	13.5	41.8	36.6	7.3	78
	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
Exeter River	2015	1.9	74.0	19.7	4.3	0.1	104
	2016	0.0	31.1	52.1	16.6	0.2	103
	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
Oyster River	2015	1.8	52.3	29.1	15.0	1.4	112
	2016	3.2	25.5	35.1	31.1	5.1	136
	2017	4.0	72.3	18.5	4.4	0.7	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
Lamprey River	2015	0.7	26.9	33.0	21.9	17.6	83
	2016	0.0	0.1	36.2	47.8	15.9	73
	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
Winnicut River	2015	No samples taken					
	2016	No samples taken					
	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					

Table 1.1-5. River herring mean, minimum, and maximum length at age from scale samples taken at the Cocheco, Exeter, Oyster, and Lamprey river fish ladders during the spring spawning run, 2021.

		Age					N
		3	4	5	6	7+	
Cocheco River	Mean	24.3	25.3	26.6	28.7	31.6	124
	Min	24.3	20.3	24.5	25.9	27.9	
	Max	24.3	28.3	29.4	31.5	34.1	
Exeter River	Mean	-	26.5	27.8	29.7	31.7	60
	Min	-	25.5	25.3	26.0	30.6	
	Max	-	27.5	29.8	32.5	32.7	
Oyster River	Mean	-	25.6	26.7	28.4	30.5	112
	Min	-	22.2	23.0	24.8	29.4	
	Max	-	28.1	30.7	31.8	31.8	
Lamprey River	Mean	-	26.5	27.7	30.2	31.3	74
	Min	-	24.6	25.1	26.8	29.5	
	Max	-	28.5	30.9	32.7	33.8	
Winnicut River	Mean	-	-	-	-	-	-
	Min	-	-	-	-	-	
	Max	-	-	-	-	-	

Table 1.1-6. Summary of river herring transfers from the Cocheco and Lamprey rivers, 2021.

Date	# Transferred	Source of river herring	Stocking location	Drainage system
4/27/2021	224	Lamprey River	Pickpocket Dam	Exeter River
4/28/2021	250	Lamprey River	Winnicut Fishway	Winnicut River
4/30/2021	1,600	Lamprey River	Pawtuckaway Lake	Lamprey River
5/7/2021	1,370	Lamprey River	Bow Lake	Cocheco River
5/14/2021	3,000	Lamprey River	Potanipo Lake	Merrimack River
5/17/2021	250	Lamprey River	Bellamy River	Bellamy River
5/18/2021	750	Lamprey River	Winnisquam Lake	Merrimack River

Table 1.1-7. Numbers of adult gravid river herring stocked in New Hampshire coastal rivers, 1985–2021.

Year	Cochecho River system	Winnicut River	Exeter River	Lamprey River system	Oyster River	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 <sup>a</sup>			320 <sup>a</sup>		220
1995	1,400 <sup>a</sup>		125	3,230 <sup>b</sup>		250
1996	750 <sup>a</sup>			2,100 <sup>a</sup>		200
1997	950 <sup>a</sup>			2,000 <sup>a</sup>		300
1998	1,000 <sup>a</sup>	300		1,975 <sup>a</sup>		240
1999	990 <sup>a</sup>	200		2,020 <sup>a</sup>		200
2000	1,000 <sup>a</sup>	430		2,020 <sup>a</sup>		320
2001	1,000 <sup>a</sup>			2,000 <sup>a</sup>		200
2002	1,000 <sup>a</sup>			1,900 <sup>a</sup>		
2003	1,100 <sup>a</sup>			2,000 <sup>a</sup>		
2004	1,050 <sup>a</sup>		100	2,000 <sup>a</sup>		
2005	1,000 <sup>a</sup>		200	2,000 <sup>a</sup>		
2006	1,000 <sup>a</sup>		40	200 <sup>a</sup>		
2007	900 <sup>a</sup>		175	2,000 <sup>a</sup>		
2008	1,000 <sup>a</sup>		250	2,000 <sup>a</sup>		
2009	500 <sup>a</sup>		250	750 <sup>a</sup>		
2010	1,000 <sup>a</sup>			750 <sup>a</sup>		
2011	2,000 <sup>a</sup>	200	659	2,145 <sup>a</sup>		
2012	1,000 <sup>a</sup>			1,000 <sup>a</sup>		
2013	480 <sup>a</sup>					
2014						
2015	1,000 <sup>a</sup>	250		1,500 <sup>a</sup>		
2016	1,000 <sup>a</sup>	250		1,000 <sup>a</sup>		
2017		250		1,000 <sup>a</sup>		
2018		250		1,000 <sup>a</sup>		
2019				760 <sup>a</sup>		
2020	600 <sup>a</sup>	250	260	1,050 <sup>a</sup>	320 <sup>a</sup>	
2021	1,370	250	224	1,600 <sup>a</sup>	300 <sup>a</sup>	

<sup>a</sup> In-river transfer.

<sup>b</sup> Combination of in-river and out-of-basin transfers.



Table 1.1-8. American Shad returns to New Hampshire coastal fishways, 1985–2021.

Year	Exeter River	Lamprey River	Cochecho River	Oyster River
1985	0	2	1	0
1986	0	39	1	0
1987	0	0	0	0
1988	*	*	4	0
1989	*	*	8	0
1990	*	*	3	0
1991	12	2	6	0
1992	22	5	24	0
1993	21	200 <sup>a</sup>	17	0
1994	*	13 <sup>a</sup>	9	0
1995	18	14 <sup>a</sup>	8	0
1996	58	2 <sup>a</sup>	5	0
1997	30	4 <sup>a</sup>	11	0
1998	33	3 <sup>a</sup>	6	0
1999	129	3 <sup>a</sup>	2	0
2000	163	7 <sup>a</sup>	14	0
2001	42	6 <sup>a</sup>	6	0
2002	41	4 <sup>a</sup>	4	0
2003	33	26 <sup>a</sup>	6	0
2004	22	33 <sup>a</sup>	12	0
2005	3	12 <sup>a</sup>	8	0
2006	2	6 <sup>a</sup>	0	0
2007	0	4 <sup>a</sup>	7	0
2008	0	4 <sup>a</sup>	7	0
2009	7	4 <sup>a</sup>	11	0
2010	0	5 <sup>a</sup>	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	0	0	0	1
2018	0	0	0	0
2019	0	0	0	0
2020	0	0	0	0
2021	0	0	0	0

\* No counts - ladder was operated as a swim through.

<sup>a</sup> Minimum counts - ladder operated as swim through until late May or early June.